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NOTE BY THE SECRETARY-GENERAL

The Secretary-General has the honour to transmit to the members of the Security Council the attached communication which he has received from the Director-General of the International Atomic Energy Agency (IAEA).

Annex

Letter dated 12 November 1991 from the Director-General of the International Atomic Energy Agency addressed to the Secretary-General

Please find attached the report of the seventh IAEA inspection in Iraq under Security Council resolution 687 (1991). You may deem it appropriate to transmit the report to the members of the Security Council. I remain, of course, available with the Chief Inspector, Mr. Demetrius Perricos, for any consultations you or the Council may wish to have.

(Signed) Hans BLIX

Enclosure

REPORT ON THE SEVENTH IAEA ON-SITE INSPECTION IN IRAQ
UNDER SECURITY COUNCIL RESOLUTION 687 (1991)

11 - 22 October 1991

SALIENT POINTS

- The existence of an Iraqi weaponization program has been acknowledged by the Iraqi authorities and confirmed; an organization chart has been obtained. Basic computations and high-explosive testing for component development had been carried out, but - if one takes the details provided by the Iraqi authorities as face value - a practical system for an implosion-type weapon had not yet been achieved.

- The Al Atheer site has been identified by the team as the prime development and testing site. The Al Qa Qaa site and the Al Hatteen High Explosive Test Site were, in the opinion of the team, also contributing to the program.

- The Iraqi authorities have admitted that buildings at the Al Atheer site were designed not only for general materials science research but also to meet the requirements of the weaponization program if a relevant political decision were taken.

- The validity of previous estimates of the extent of the centrifuge enrichment program has been further confirmed by this team, but no cascade or likely site was found. Iraq once again insisted that its entire uranium enrichment program has been declared.

- Feasibility studies on uranium enrichment by the gaseous diffusion method were admitted by the Iraqi authorities. These studies, which included laboratory work on diffusion barriers, were carried out from 1982 until 1987, when the program was phased out.

- Destruction or rendering harmless of centrifuge and EMIS components has started. All known equipment used in the manufacturing of centrifuge and EMIS components has been inspected and identified by means of IAEA seals with a view to future destruction or rendering harmless.

- The glove boxes associated with the clandestine production of approximately six grams of plutonium have been rendered harmless by having cement poured into them. The associated hot cells have been impaired by cutting of the manipulators. Further action is necessary to deal with the hot cells and other equipment.

- Some items of equipment were identified by means of IAEA seals pending a decision on their destruction or removal or the monitoring of their use.

- Measurements of the activity of the irradiated fuel in the IRT-5000 reactor and at storage location B continued. These measurements are intended to confirm the integrity of the fuel and the correctness of Iraqi statements regarding the extent of the irradiation to which the assemblies were subjected. Thirteen assemblies which were difficult to access have still to be verified.

- The two transport specialists who accompanied the team completed the initial preparations for the shipment of fresh fuel. This fuel will be removed from Iraq in the middle of November.

- The compilation of an inventory of the nuclear material (uranium concentrates and various uranium compounds, oxide powder etc.) accumulated at storage location C continued. This nuclear material, included in the lists attached to the Iraqi declarations made since 7 July 1991, consists of several hundred tons of nuclear material in many forms, scattered over several sites throughout Iraq. As a consequence of having been hurriedly removed for purposes of concealment from inspectors, in some cases the material is wrongly identified and the associated records are incomplete. This work will have to continue.

- Evidence of uranium enriched to 93% has persistently shown up in samples collected in and near Al Tuwaitha (at four different locations). This material is isotopically distinct from the 93%-enriched French fuel and is unlikely to be a product of the Iraqi enrichment program. The Iraqi authorities deny ever acquiring or producing such material. This important issue is still open and under investigation.

- Inspection visits were made to a number of new sites designated by the Special Commission, but only in the case of one site (Al Hadre) could the findings be related to a future use in the weaponization program.

INTRODUCTION

1. This report summarizes the findings of the seventh inspection carried out by the IAEA under Security Council Resolution 687 (1991) with the assistance and co-operation of the Special Commission of the United Nations. The inspection took place from 11 to 22 October 1991 and was headed by Mr. Demetrius Perricos of the IAEA as Chief Inspector. The team consisted of 26 inspectors and 13 supporting staff; it comprised 17 nationalities. During the inspection 18 sites and locations were visited. These are shown on the map of Iraq attached to this report.

   The objectives of the inspection were broadly

   - to assess the extent of the Iraqi studies and experiments directed towards developing a nuclear weapon (referred to throughout this report as "weaponization").

   - to further investigate the work done and progress made in enrichment, particularly by the centrifuge method.

   - to continue the work of the fifth inspection team in measuring and verifying the declared nuclear material.

   Each of these three broad objectives was assigned to a separate group within the overall team, with a group leader responsible for co-ordination of the work within each group.

2. In the area of weaponization, a major clarification was obtained of the stage reached by Iraq. As a result of persistent investigation and questioning, the Iraqi authorities have now acknowledged that efforts had been under way to establish the design parameters and development work needed for a nuclear weapon. The acknowledgement is contained in a letter annexed to this report (Annex 1). The importance of this letter lies in its confirmation of the IAEA's conclusions and of the validity of the documents found during the sixth inspection, in September. The team believes that computations and experimental work had been carried out on a basic weapon model but had not yet yielded a workable production design. The studies and experiments had covered detonator initiation, the hydrodynamics of a compressed explosive system and basic explosive lens design, but they were still at an early stage.

3. Particularly important were the determination by the team and the admission by Iraq that the Al Atheer site was built not only as a materials production development site (as declared by Iraq; see letter in Annex 2) but also to serve the weaponization program once a decision was taken. This had been persistently denied by Iraq in the past.

4. As a result of the findings relating to weaponization, the Iraqi authorities have now produced an organization chart of the Iraqi Atomic Energy Commission which includes the weapons program operation under the code name Petrochemical-3, PC-3 (Fig. 1). This confirms that there was a large, well organized program employing several thousand people. Iraq still insists, however, that the work was intended only to establish the technical basis for a political decision to proceed to a weapon and that the political decision had not been taken. Figure 2 shows the main facilities involved in the weaponization and the enrichment program.

5. A primary focus of the inspection effort expended in Iraq thus far has been on identifying and characterizing the Iraqi uranium enrichment program, the goal being to understand it to the extent necessary in order to destroy it or render it harmless and to establish the basis for ongoing monitoring. With the completion of the seventh inspection, the team's opinion is that the emphasis of the inspection effort, as regards the Iraqi uranium enrichment program, should now move gradually from identification and characterization to monitoring. All known sites involved in enrichment R&D and component manufacture and production have been inspected. Process components generally consistent with the known extent of the enrichment program have been inventoried, and destruction has started. Similarly, component manufacturing equipment consistent with the known enrichment program deployment and plans has been identified and sealed for destruction or monitoring. Efforts by Iraq to hide the nature and extent of the enrichment program and some remaining inconsistencies leave open the possibility that the full Iraqi program has not been disclosed.

6. The report of the fifth inspection team described the difficulties of adequately verifying the additional nuclear material declared by Iraq on 7 July and subsequently. This material was placed under seal by the third inspection team pending verification. The difficulties relate to the inadequate documentation, labelling and packing of the material, which is in the form of ore, uranium oxide and miscellaneous chemical compounds. These arise from the originally undeclared production of compounds such as uranium hexafluoride (UF_6) and uranium tetrachloride (UCl_4) which were used in clandestine enrichment development work. The seventh inspection team continued to compile an inventory of this material and to verify it. The demands of other activities, however, drastically reduced the inspection manpower available. It will therefore be necessary to continue with its work during subsequent inspections.

7. As part of the task of monitoring the fresh and irradiated fuel kept in sealed storage in Iraq, it is necessary to periodically examine seals and in some cases to remeasure samples of the total fuel population. During this inspection, measurements were made of the 36%-enriched fuel and of the 93%-enriched French MTR-type irradiated fuel. It is expected that by the middle of November 1991 the fresh fuel will be removed from Iraq, reducing the task of periodic reverification. The two transport specialists attached to the team made the necessary initial preparations. Measurements were also made of some of the elements in the IRT-5000 reactor core and storage pond as part of the task of assessing the validity of the Iraqi declaration regarding irradiation.

Figure 1

Iraqi Atomic Energy Commision

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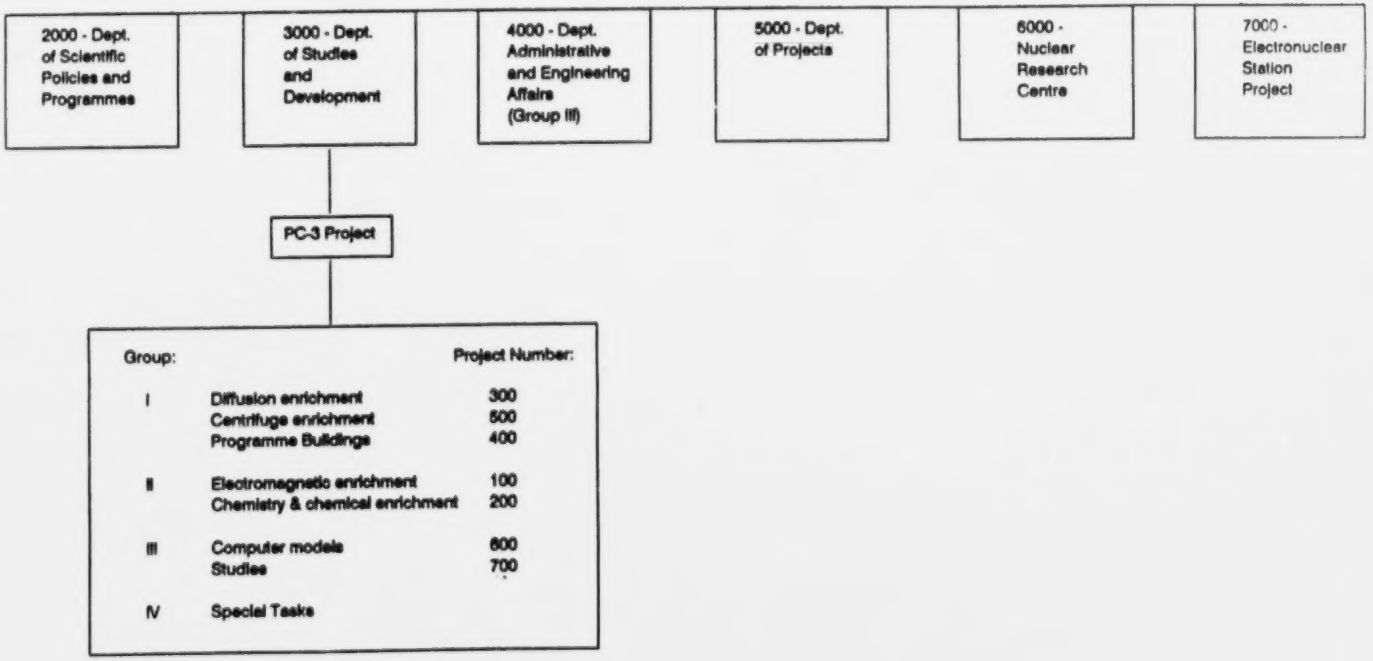

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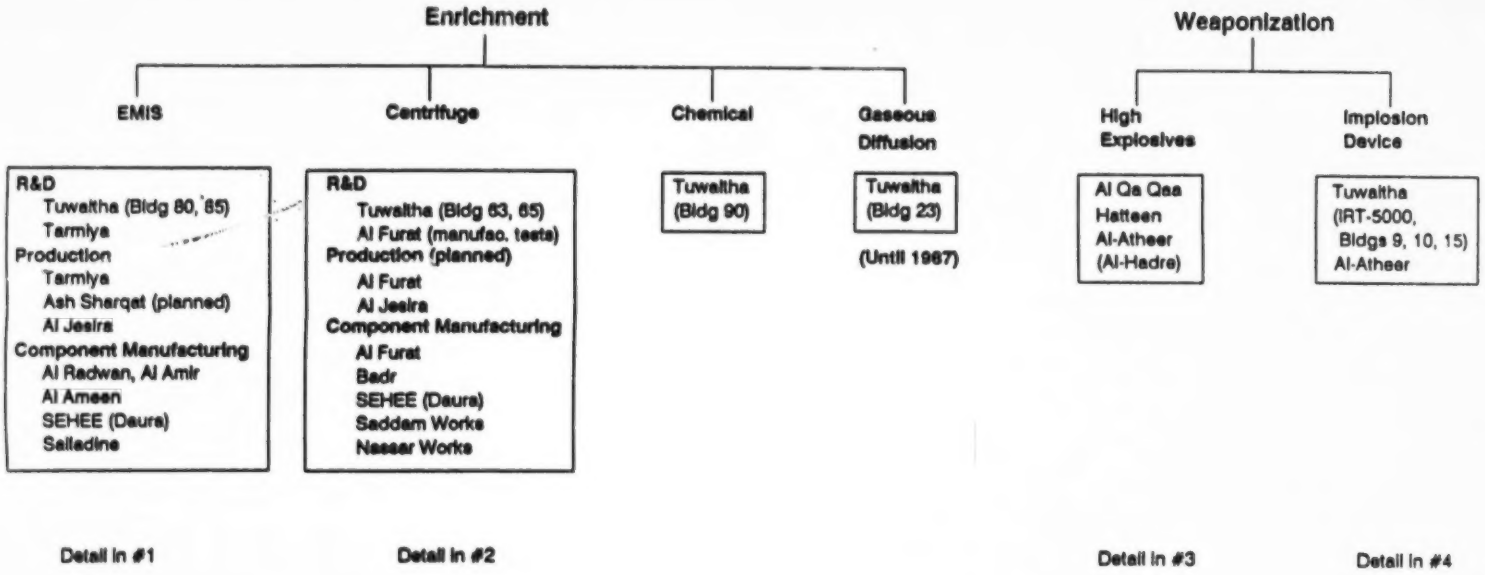
Figure 2

Main Facilities Involved in the Enrichment and Weaponization Programmes



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8. The hot cells used to produce approximately six grams of plutonium clandestinely had previously been placed under seal. During this inspection these cells were impaired by cutting the working mechanisms of the manipulators. The glove boxes associated with this program had cement poured into them in order to render them useless.

9. Several samples taken in and around Al Tuwaitha indicate the presence of uranium enriched to approximately 93% in uranium-235. This material is isotopically distinct from the 93%-enriched French reactor fuel. Iraq strongly denies that it has or ever had such material. It is highly unlikely that this material is a product of the Iraqi uranium enrichment program. This important issue is still open and under investigation. Additional samples were taken for this purpose.

10. A feature of the seventh inspection was the large amount of correspondence between the Chief Inspector and the Iraqi counterpart while the team was in Iraq. The purpose of the many communications from the Chief Inspector was to unequivocally establish the Iraqi answers to key questions about the nuclear program. Experience has shown that oral questioning is insufficient for obtaining definitive statements and that very careful phrasing is required in order to convey precisely what is being asked. A full record of the correspondence is given in Annex 3.

THE IRAQI NUCLEAR WEAPONIZATION PROGRAM

11. The seventh IAEA inspection mission has confirmed that for a number of years Iraq devoted considerable resources to a research and experimentation program of nuclear weaponization. One of the objectives of the seventh IAEA inspection was to assess the achievements of this program by analysing available documents found in Iraq during the sixth IAEA inspection and the results of previous inspections.

General design of the explosive device

12. Within a general classification of nuclear weapon designs into three categories,

- Gun type
- Intermediary implosion type
- Advanced implosion type

it can be concluded that the main effort of the program was concentrated on the second category.

In fact, no documentary evidence or experimental equipment which could be related to a gun-type design has been found or disclosed. The same applies to advanced implosion-type devices.

The production of lithium-6 may be considered indicative of an orientation towards "boosted" devices in the long term, and one may infer that Iraqi scientists intended to explore this concept at a later date.

Core geometry

13. Progress reports on the PC-3 project (the code name for the Iraqi clandestine program) which are in the possession of the IAEA give a general description of the core geometry.

Several geometric configurations had been tested with hydrodynamic computer programs, in both mono- and bi-dimensional lattices. Some of these programs had been modified in Iraq for use on IBM PS/2-80 computers. The limitations of such computers are compensated by the fact that - as available literature indicates - comparable solutions have already been reached in experimentation. The same may be said for neutronic codes, which can provide acceptable results when the precision required for the yield value is not a fundamental design parameter.

Uranium metallurgy

14. It has been determined and documented that work covering the various phases of uranium metallurgy was conducted at Al Tuwaitha prior to the destruction of the relevant facilities. Buildings 10 and 15 were used for UF_4 production, uranium metal reduction and metal casting and machining (see Table 1 and Fig.3).

15. The IAEA inspection team confirmed, through documents and on-the-spot visual evidence, that the Al Atheer facility (fig. 4) was designed, inter alia, for large-scale uranium metallurgy. Induction furnaces, plasma coating machines, computer-controlled drills and lathes with recoverable chippings were identified in Buildings 50 ("casting"), 55 ("powder") and 84 ("carbide"). Smears and samples taken during the seventh inspection will indicate whether those facilities were used between July 1990 (date of completion of Building 55) and December 1990 (date when the facilities were evacuated prior to bombardment).

16. No assessment can yet be made concerning the amounts and types of weapons components (reflectors, tampers, flying plates, etc.), if any, which could have been produced at Al Atheer during that period. It can only be stated that the necessary knowledge and equipment for uranium metallurgy had been acquired. Most of the equipment, being dual-use in nature, has been put under seals by the seventh IAEA inspection team. The entire Al Atheer site, including the firing test bunker, deserves ongoing monitoring.

Explosive assembly

17. The Iraqi authorities declared at the end of the fourth inspection that they were in possession of large quantities (hundreds of tons) of HMX explosive. Part of it was used for filling aerial bombs. The remaining quantity (255 tons) was inventoried and put under IAEA seals in six storage bunkers at Al Qa Qaa by the seventh inspection team. It is obvious that, with such quantities available, the few tons necessary for a nuclear weaponization program did not represent a problem.

18. Two isostatic presses (hot and cold) suitable for shaping explosive charges and with sufficient capacity and and also various items of remote-controlled machining equipment with adequate cooling were located at Al Atheer. Should this equipment have been utilized, the possibility cannot be ruled out that some explosive structures were produced and are still being stored somewhere.

19. The fabrication of explosive "lenses" for experiments was mentioned in the PC3 progress reports. Two types of lenses seem to have been tested, probably at the Al Atheer "bunker", from March to May 1990: dual-explosive and flying-plate lenses. The experiments appear to have been limited to planar shock waves. However, it is prudent to assume that Iraqi scientists have a basic knowledge of the initiation of a spherical implosion.

Table 1

Buildings involved in weaponization and enrichment

TUWAITHA

Building No	Description of Building	Activity
3	Administrative Building	Personal computers for hydrodynamic models
9	Chemical & Radiochemical Analysis Laboratory	Separation of Pu from exempted pins Separation of Pu from irradiated pins Production of Po-210 sources
10 10 annex	Chemical Analysis Laboratory Nuclear Physics Department	Production of U metal Melting and casting of metal uranium
13	Research Reactor IRT-5000	Irradiation of EK-10 and EK-07 cassettes Irradiation of Bismuth for Po-210 production
15	Isotope Production Laboratory	Production of UF_4 and UF_6
16	Workshop	Initiator workshop
23	Laboratory Workshop Building	Gaseous Diffusion Enrichment Ceramic capacitor fabrication
24	Tamuz-2 zero Power Reactor Tamuz-2 Hot Cells	Storing of irradiated cassettes Disassembling of cassettes Neutron measurements
35	Radioactive Waste Treatment Station (RWTS)	Handling of wastes from the irradiation programme
63	Cold material testing laboratories	Gas centrifuge enrichment
66	Training Building	Initiator System Examination
73	Experimental Fuel Fabrication Laboratory	Manufacturing of EK-07
80	Nuclear Physics Laboratories	EMIS
82	Electronic Research Laboratories	Electronic systems
85	Chemical Research Laboratories	Production of yellow cake, UO_2 and UCL_4
90	Polymer chemistry Research Laboratory	Enrichment by solvent extraction and ion exchange Li-6 enrichment research

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Figure 3

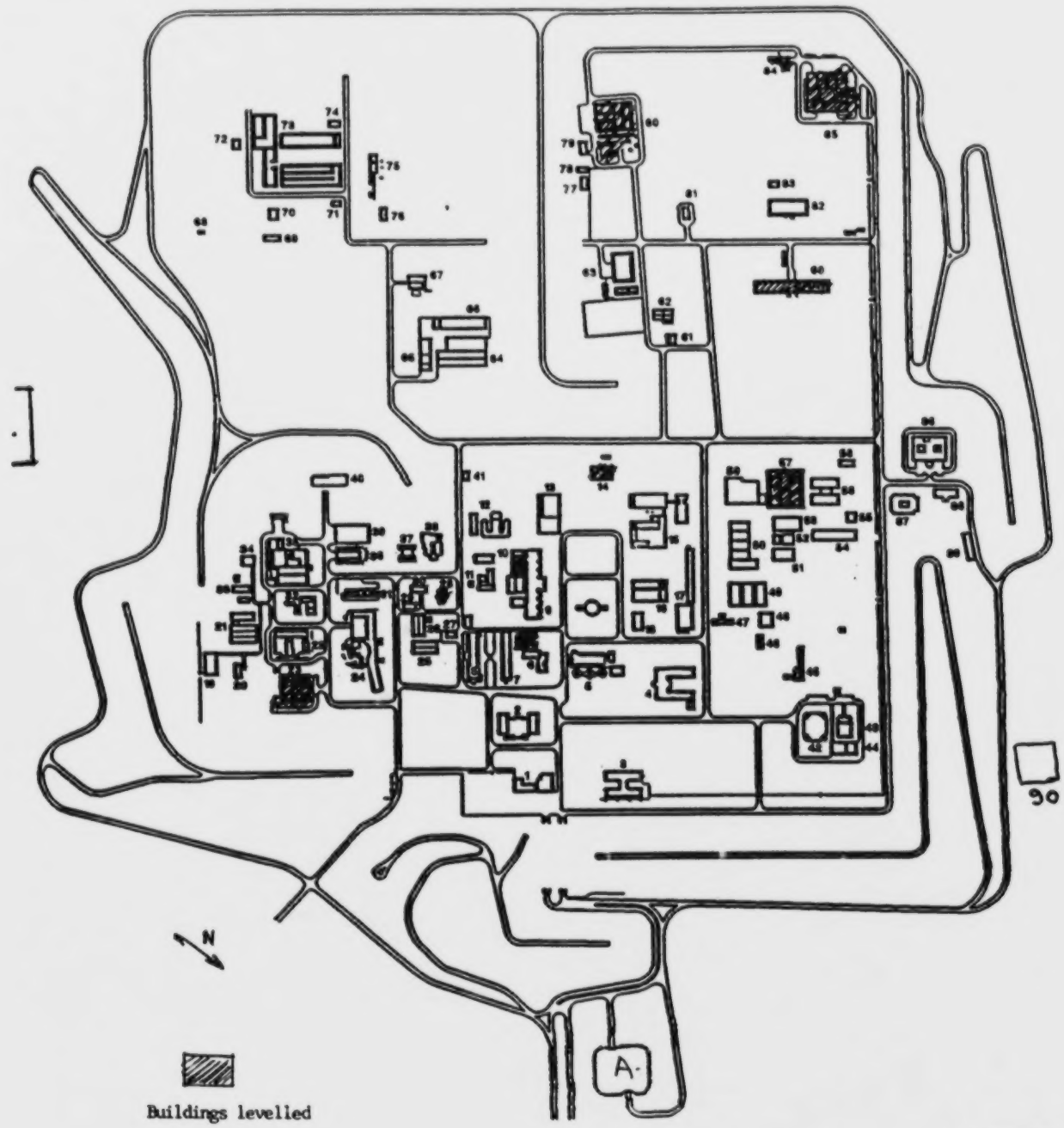
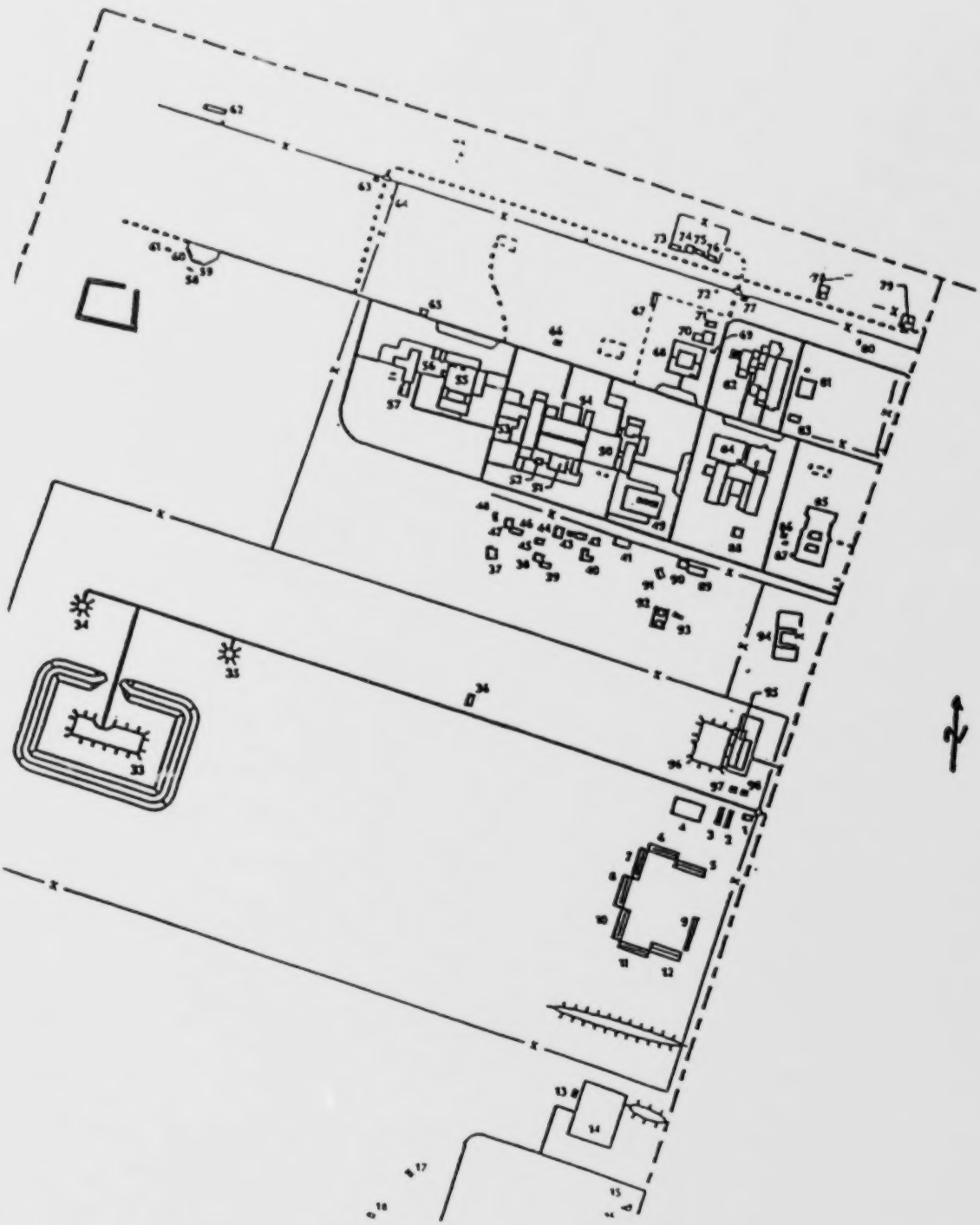


Figure 4

AL ATHEER SITE



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20. Facilities for hydrodynamic studies and explosive testing exist at Al Atheer and Al Hadre. At Al Atheer, the "bunker" (under the authority of the Al Hatteen Establishment) has been visited several times by IAEA inspectors. It is overdesigned for its declared use. The existence of two high-speed streak cameras at Baghdad University (resolution 100 picoseconds) confirms that precise detonic experiments were possible. The Al Hadre site was a new site designated by the Special Commission. An open firing range for air-fuel bombs and fragmentation testing, it is a very suitable place for experimentation with entire explosive structures. The control bunker is equipped with electronic devices which appear overdesigned for their declared use.

It may be concluded that the explosive structure of an implosion-type device did not pose an insurmountable problem for Iraqi scientists. The facilities at Al Atheer and Al Hadre merit close ongoing monitoring.

Firing system

21. The quality level attained in the firing system for nuclear weapons remains a question mark in the Iraqi program. In general, the results of IAEA inspections suggest that the local capabilities in electronics were not on a par with the competence in metallurgy, chemistry and detonics.

22. The exploding bridge wire detonators (EBW) could not be imported, and were developed locally at Al Qa Qaa in the course of project 144. Documentary evidence links project 144 to the PC-3 program, although the Iraqi authorities had previously stated that EBW development was carried out to produce explosive bolts for the separation of two stages of a space rocket. The specifications were for simultaneity better than 0.5 microsecond. According to Iraqi statements, the experiment failed.

23. The locally fabricated capacitors do not seem to possess the characteristics necessary for storing the energy required by the multiple detonator system specified in the project design. Two of these capacitors have been brought back to Vienna.

Neutronic initiator

24. The initiator on which the Iraqi engineers were experimenting with a pneumatic cannon system is a polonium-beryllium internal source. Traces of polonium-210 have been found at Al Tuwaitha locations. Studies on alternative internal initiators, based on other alpha sources or on external initiators relying on intense plasma focus, are mentioned in Iraqi progress reports, but there is no indication that they had yet resulted in a workable solution.

Summmary of the present assessment of achievements

25. To the best of the team's knowledge, based on Iraqi progress reports found and on the results of the IAEA inspections in the field, the status of the Iraqi work on the various pathways leading to nuclear weaponization is as shown in Figures 5 and 6; it can be summarized as follows:

Figure 5

Weaponization Program - Core and Initiator

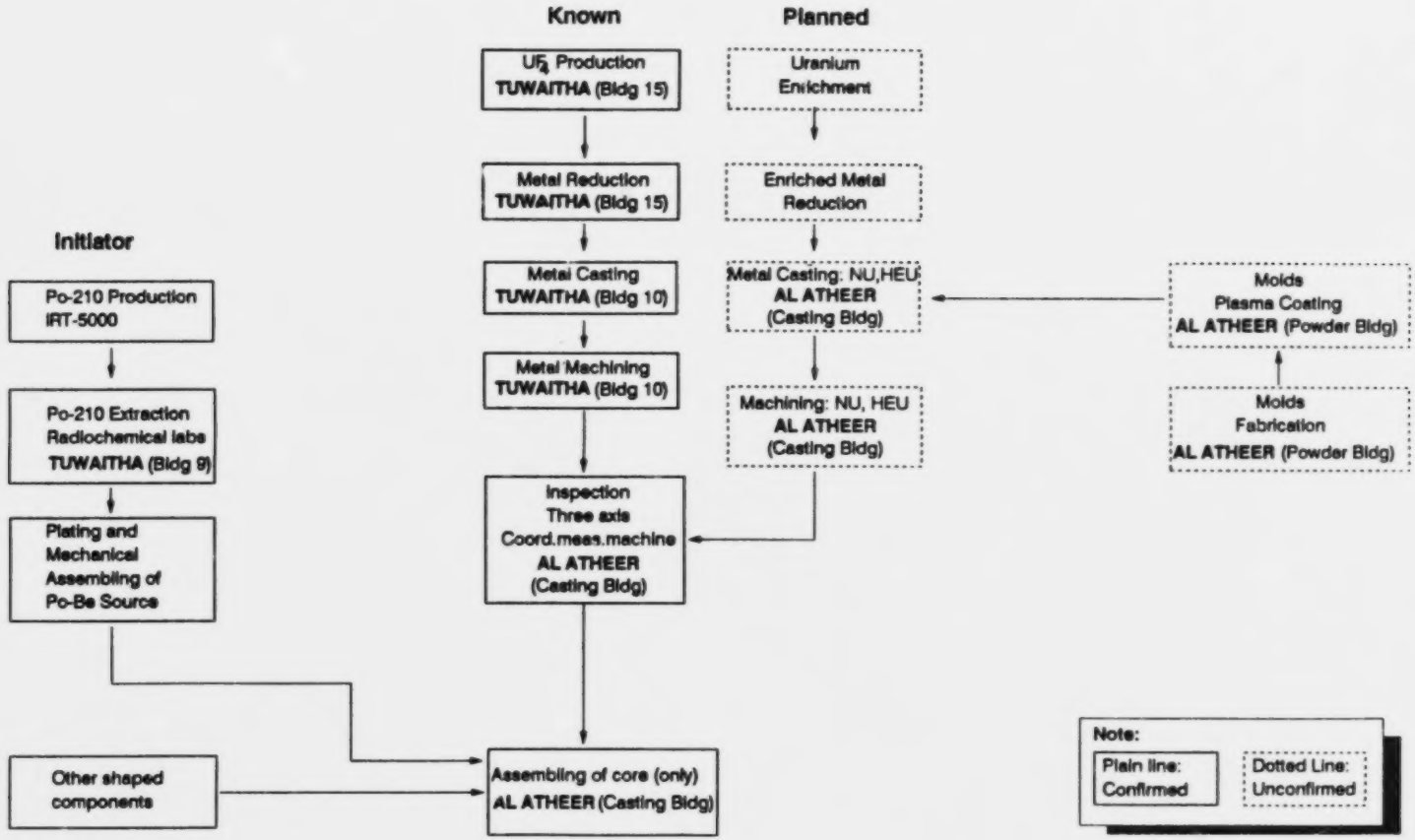
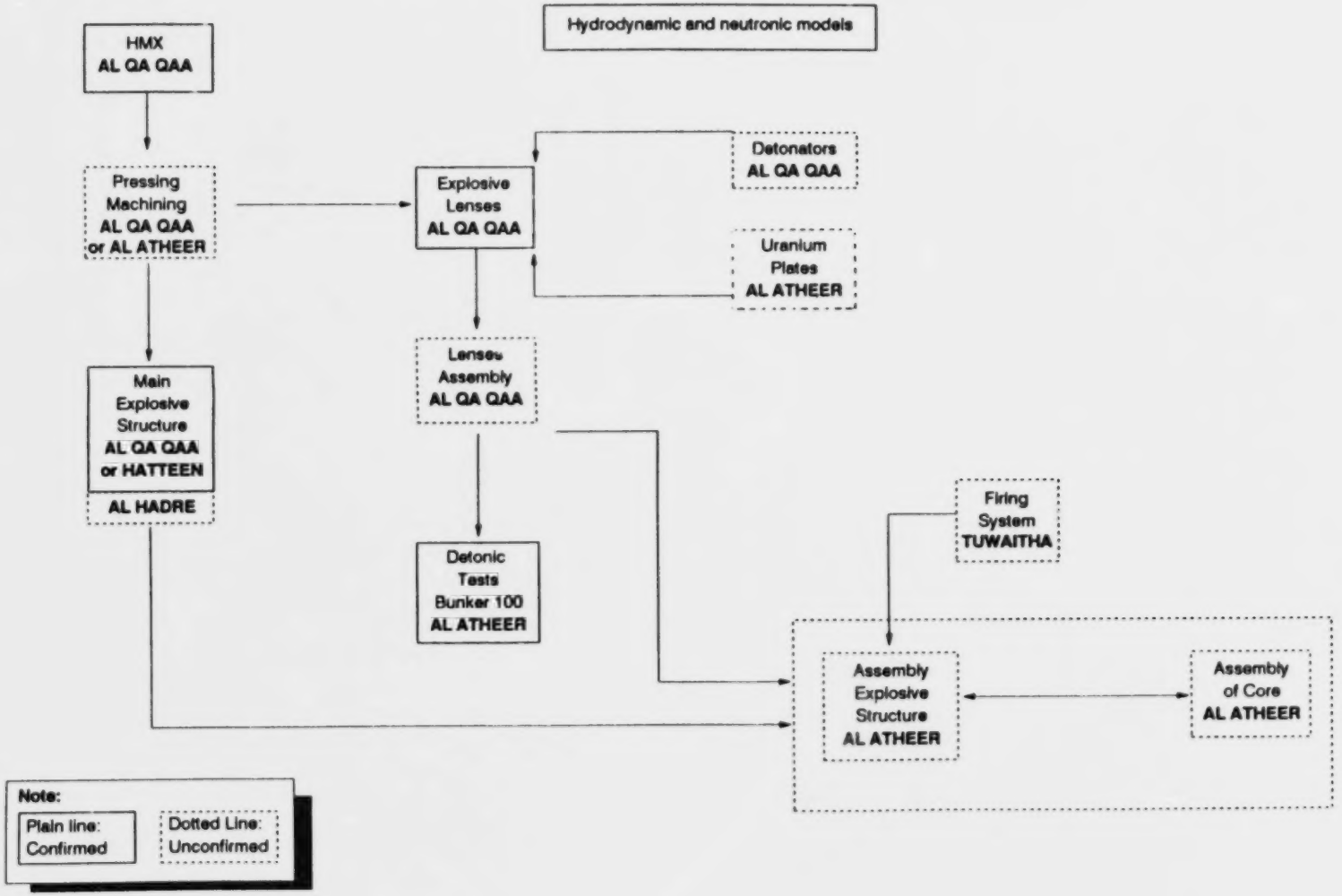


Figure 6

Weaponization Program - Explosives



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Iraq has acknowledged that it was actively pursuing a research and development program with the goal of developing a "practical" design for a nuclear explosive. The explosive design type chosen by Iraq represents an intermediate-level technology that uses enriched uranium in an implosion system.

26. The description of the nuclear-weapon design is incomplete. The main-charge high explosive was not addressed. However, the program as presented by the Iraqi authorities was a broad one encompassing all of the challenging features required - core, high-explosive lenses, detonators and firing system. The description of the design and of the work performed appears somewhat superficial in that it consists almost entirely of information that could be obtained through a literature search. Almost no information of a creative nature, results of detailed calculations or experimental results have been offered. The experiments as described were quite simple and the comments - if taken at face value - indicate that Iraq still had a long way to go.

27. It is important to note that other options, involving both lower and higher technologies, were available. Given their thorough use of the literature, the Iraqi scientists were undoubtedly aware of these options. The lower-technology approach, a gun assembly type design, offers two significant advantages and one major disadvantage: the advantages are a much higher chance of success in a short time and much greater ease of concealing the design phase of the program; the disadvantage is the greater requirement for nuclear material as compared with the implosion design. Possibly the Iraqi scientists felt that their understanding of a gun-type weapon was such that, if the fissionable material became available, the nuclear explosive could be manufactured with a low-observability test program in a very short time. Furthermore, because the implosion design requires significantly more effort and time to develop, they chose to concentrate their efforts on a design which would give them potentially two options when the nuclear material became available.

28. The Iraqi scientists appear to have been interested also in designs corresponding to technology levels higher than the "basic mechanism" implosion type. Work with lithium, particularly the enrichment of lithium-6, was probably associated with efforts to develop higher-level explosive technology, most likely as part of a continuing long-term program. The Iraqi authorities refer to "academic curiosity", "employment of chemists" and "medical products" as justifications for this effort, but it is noticeable that all documents on the subject are marked "top secret".

THE IRAQI URANIUM ENRICHMENT PROGRAM

29. The Iraqi uranium enrichment program began in 1982, following the Osirak bombing. Work, at one time or another, on four uranium isotope separation technologies has been confirmed - primarily electromagnetic isotope separation (EMIS) and gas centrifuge enrichment.

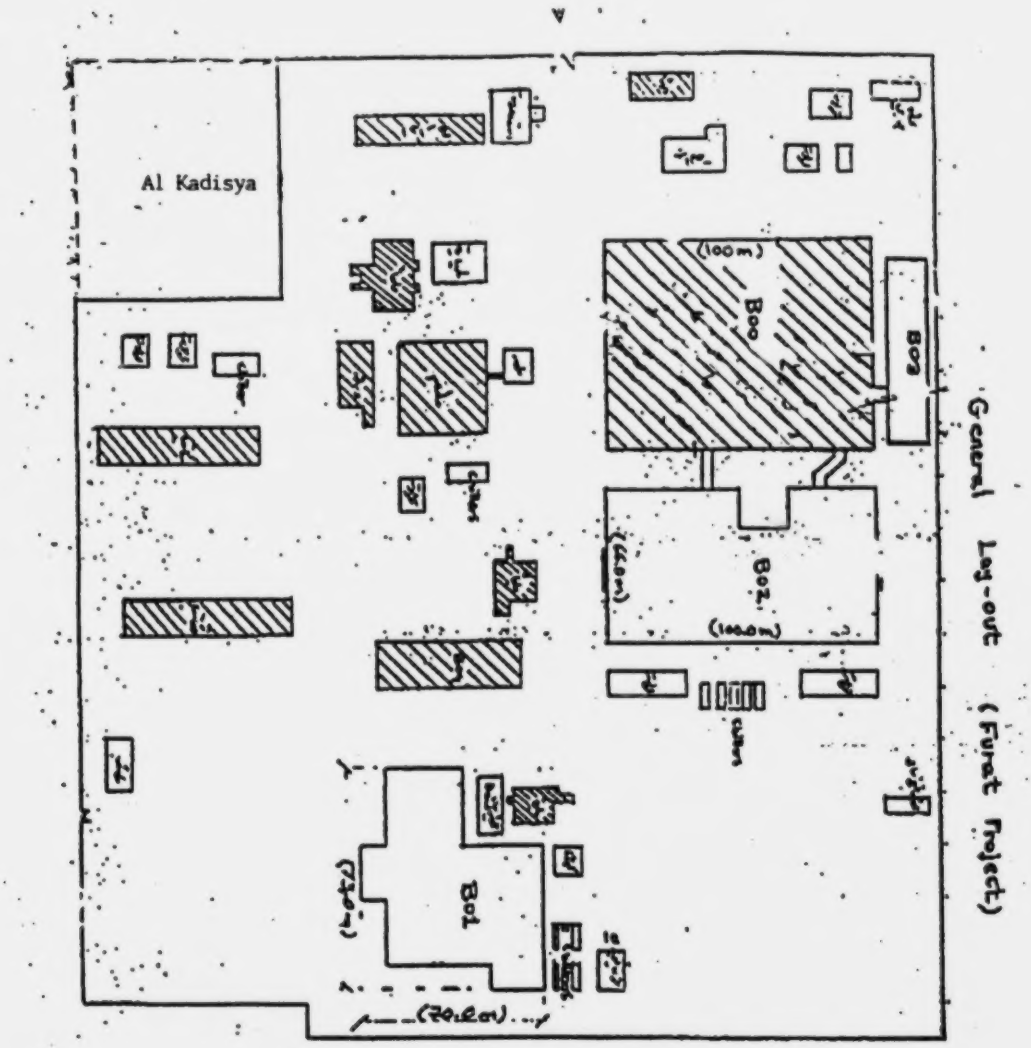
30. A large R&D effort covering all aspects of EMIS technology was carried out at the Al Tuwaitha Nuclear Research Center. Industrial-scale production facilities were being constructed at the Tarmiya and Ash Sharqat sites. Eight EMIS units were operating and additional units were being installed at Tarmiya at the time the facility was destroyed. Construction at the Ash Sharqat site continued up to the Gulf War. Most major buildings at both sites were heavily damaged, particularly at Ash Sharqat. The EMIS development and deployment was largely an indigenous effort.

31. Serious development work on centrifuge enrichment began with single-machine (Model 1) trials in mid-1987. Design and performance testing was carried out at Al Tuwaitha. Work had progressed from a Beams type centrifuge to a Zippe type (Model 2) counter-current centrifuge by mid-1988. The centrifuge enrichment program was proceeding rapidly to industrial-scale centrifuge manufacture and deployment. A large manufacturing and testing facility was being constructed at Al Furat (Fig. 7) and all necessary manufacturing equipment (for centrifuges utilizing maraging steel rotor tubes) had been procured. This big jump from a very modest R&D program to large-scale industrialization was apparently made possible by substantial help from outside Iraq. Iraq had acquired the design and the basic manufacturing technology, but had not achieved full implementation at the time work stopped. Development work involving single-machine optimization trials (Model 2 with carbon rotor tubes obtained from abroad) proceeded concurrently with the efforts to master the production of maraging steel components. The manufacturing equipment intended for installation at Al Furat was adequate for the production of more than 2,000 centrifuges a year. The centrifuge enrichment program was definitely not an indigenous development effort. The decision to proceed with maraging steel rotors would have minimized the difficulties posed by export controls.

32. R&D was also devoted to chemical exchange isotope separation and gaseous diffusion. Little remains of the Iraqi work on chemical exchange separation. The few reports describe results readily available in the open literature. Presentations by Iraqi scientists to inspection teams indicate that their work in this area had not progressed very far. The Iraqi scientists admit to a serious feasibility study (with some laboratory work on barrier material) of gaseous diffusion. Their conclusion was that Iraq lacked the industrial infrastructure necessary for large-scale deployment and abandoned the effort in mid-1987. There is no indication that Iraq pursued laser or jet nozzle enrichment technologies.

Figure 7

THE AL FURAT CENTRIFUGE PRODUCTION COMPLEX



33. Schematics describing the R&D, manufacturing and production facilities for EMIS and centrifuge enrichment are given in Figures 8 and 9. A detailed description of the Iraqi uranium enrichment program is provided in Annex 4. The sites involved in EMIS development (Al Tuwaitha and Tarmiya), component manufacture (Al Radwan, Al Amir, Dijla and SEHEE) and production (Tarmiya, Ash Sharqat and Al Jesira) have been identified. All facilities were badly damaged during the war. The conclusion of the third inspection team that the Ash Sharqat facility never operated has been confirmed.

34. Results from environmental samples taken at Tarmiya and in the vicinity of Buildings 80 and 85 at Al Tuwaitha (location of EMIS development work) are consistent with Iraqi declarations regarding the levels of enrichment obtained. However, environmental samples collected in other areas in and around Al Tuwaitha indicated the presence of 93%-enriched uranium with significant amounts of uranium-236. The source of this material remains an important open issue requiring further investigation, but it is highly unlikely that it resulted from Iraqi enrichment activities; the Iraqi authorities deny ever acquiring or producing such material.

35. EMIS components that were scattered about a number of sites around Baghdad have now been moved to a central location (Al Nafad) near Al Tuwaitha. The Iraqi declaration is consistent with the known extent of EMIS development and deployment. This declaration has been verified and all equipment not destroyed during the war has been either destroyed under the observation of the seventh team or marked for destruction when the means to destroy them have been found.

36. Manufacturing equipment used to produce EMIS components has been identified and marked with IAEA seals; it is destined for destruction or monitoring.

37. The known sites involved in centrifuge enrichment development (Al Tuwaitha), component manufacture and material production (Al Furat and Al Jesira) have been thoroughly inspected. The facilities at Al Tuwaitha and Al Jesira were destroyed; the Al Furat site was far from completion when work stopped.

38. All known centrifuge components have been either removed by the inspection team or destroyed. Manufacturing equipment consistent with the Iraqi program has been identified and marked with IAEA seals. Key equipment - such as a flow turning machine, electron beam and MIG welders, and oxidation furnaces - have been marked for destruction. The assessed extent of use of the equipment is considered to be generally consistent with Iraqi declarations.

39. Manufacturers of equipment and components have been identified for follow-up investigations.

40. All sites and equipment not destroyed are subject to monitoring. Past efforts by Iraq to hide the nature and extent of the enrichment program, the lack of firm procurement/project documentation and inconsistencies as regards quantities of centrifuge components declared contribute to the uncertainty as to whether the full Iraqi centrifuge enrichment program has been uncovered. Special short-notice inspections will continue to be carried out as part of the long-term monitoring regime. A number of follow-up activities for future inspection teams have been identified.

Figure 8

Iraqi EMIS Programme

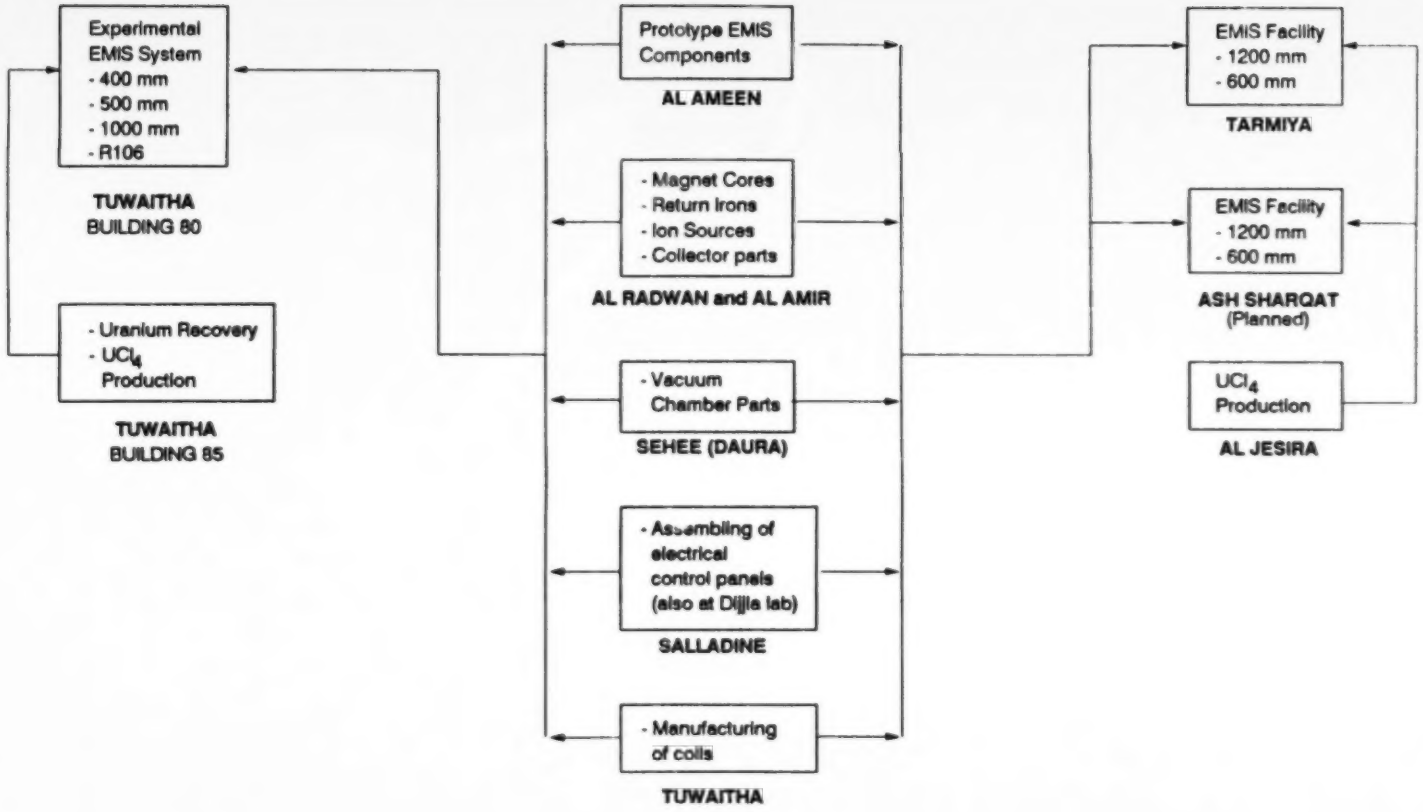


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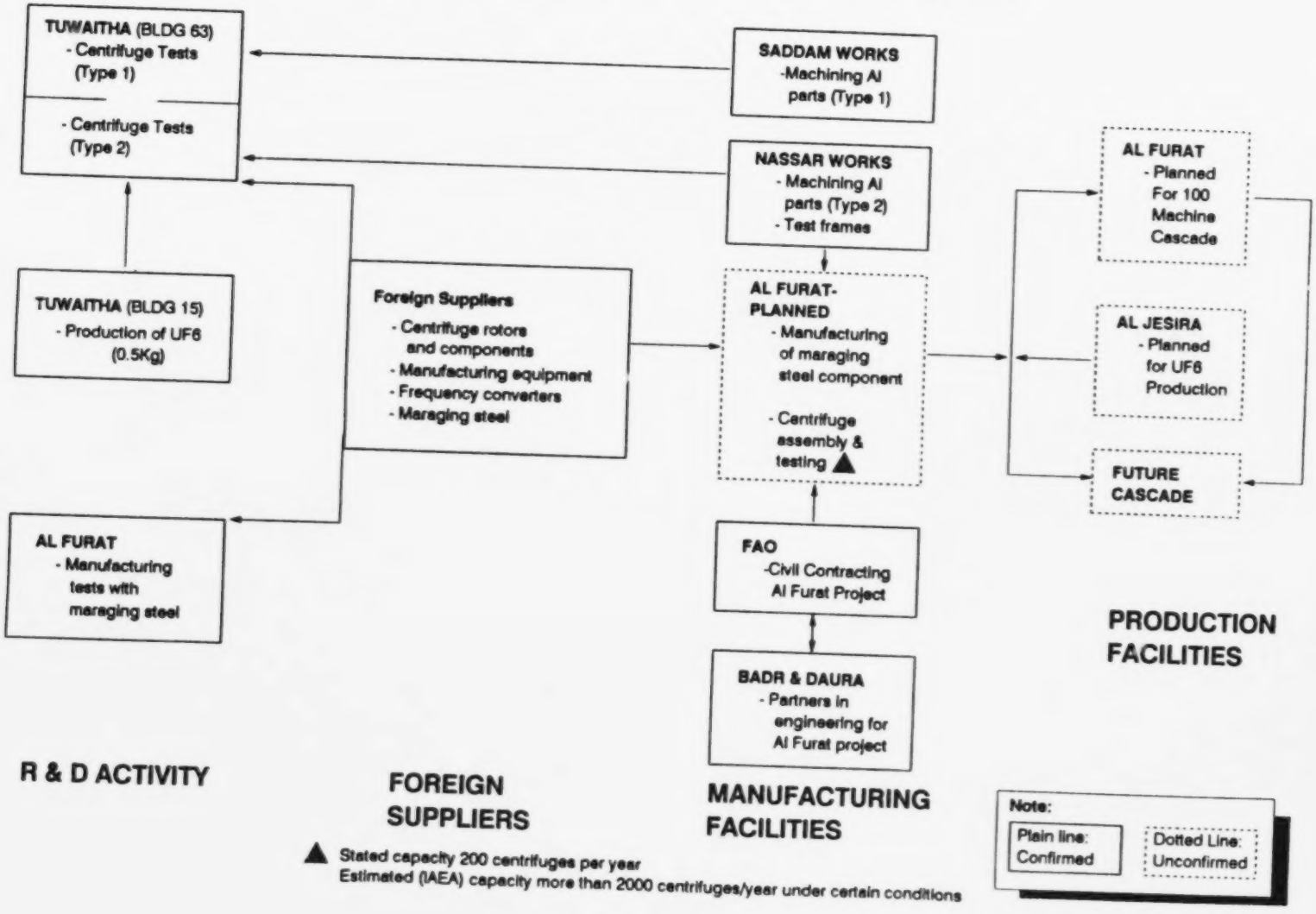
Figure 9

Iraqi Centrifuge Enrichment Program



▲ Stated capacity 200 centrifuges per year
Estimated (IAEA) capacity more than 2000 centrifuges/year under certain conditions

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NUCLEAR MATERIAL VERIFICATION AND MEASUREMENT

Fuel elements

Fresh fuel at location A:

41. The ten 36%-enriched EK 36-type rod cluster fuel elements were item-counted and reverified. Eight items were remeasured. One element was disassembled, and nine of the fifteen rods composing it were measured to check the internal consistency of their composition. All results are consistent with the Iraqi declaration.

In preparation for shipment, all storage drums were opened. The items were counted, the element support structures were rebuilt, and the elements were repackaged into eleven sealed drums. Some mechanical work was necessary to ensure that the drums were sound and safe for air transport. This material will be transported out of Iraq in mid-November.

One of the 2.2%-enriched rods (appr. 10 cm long) was moved to the "New Storage" and placed in a sealed cabinet. It was chosen as a standard for fuel measurement NDA work.

Irradiated fuel at location B:

42. The thirty-two 93%-enriched French MTR-type lightly irradiated elements were reverified. Three of the six control elements were scanned along their lengths with a dose meter. The Iraqi side supplied diagrams of a typical Tamuz-2 reactor core configuration and a schematic drawing of the control elements. The measurement results are consistent with the Iraqi declaration. All seals were checked and eight were replaced. The previous inspection team had encountered measurement difficulties due to the low level of water in the storage tanks, and the Iraqi authorities had been asked to increase the level. This has now been done in seven tanks.

IRT-5000 reactor

43. All fuel elements were counted and five were verified using a Ge-Li detector, including two which were declared to have been irradiated for only several hours. It was demonstrated that an element could now be removed from its storage position in the spent fuel pond without dust being raised in the water. This will enable the 13 previously inaccessible elements to be verified during a future inspection.

Beryllium (Be) inventory

44. Seventeen Be assemblies and the Be central neutron trap have been declared as associated with the IRT-5000 reactor; 13 of the assemblies and the trap remain in the core, three assemblies are in the reactor storage racks and one (not irradiated) is

under seal in the "New Storage" cabinet. The items were counted and three were brought to the water surface for visual inspection and a dose measurement (< 100 mS/hr at 10 cm in air). Seven Be assemblies have been declared as associated with the Tamuz-2 reactor. They are in a barrel stored in pit 15 at location B. They were counted, and three were removed from the barrel and from their plastic wrapping for visual identification and dose rate measurements. A sample was taken from one of them. The barrel was sealed. The verification results so far are consistent with the Iraqi declaration.

Nuclear material in bulk form

45. A major objective of the IAEA inspections has been to physically verify all the bulk nuclear material in Iraq. However, most of this material (several hundred tons, mainly in powder form) had been clandestinely produced or imported. As a consequence of attempts to hide this material during the early inspections, the identifications on the containers and the associated paperwork are in some cases incorrect or incomplete. Moreover, during earlier attempts at clarification, complications arose as further declarations were made and new material provided.

These difficulties were commented on in earlier reports. The fifth inspection report in particular notes that it would require a full team working for at least a week to adequately verify the material and clarify the situation. Before the seventh inspection it was decided to attempt to verify all the material at storage location C (consisting of ore, yellow-cake, uranium oxide powders and scrap material from the enrichment process) and examine the associated records, and not to attempt to verify the material at sites other than Al Tuwaitha.

46. Table 2 summarizes the verification activities performed by the seventh team and includes the results obtained from verification by the third and fifth teams. The nuclear material flow chart in Figure 10 is based on information collected. Details of the bulk material verification are given in Annex 5.

A final conclusion about the amounts and categories of nuclear material presented in the different Iraqi declarations cannot be drawn until a full evaluation of the non-destructive and destructive analyses is performed. All material at location C has been left under seal.

ACTIVITIES RELATED TO PLUTONIUM PRODUCTION

47. The activities related to plutonium production at Al Tuwaitha were analysed. Four campaigns of one assembly each were processed in the hot cells of Building 9. The first campaign was for plutonium recovery from one exempt fuel element with an initial enrichment of 10% from the IRT-5000 reactor. The other three were for plutonium recovery from indigeneously produced Iraqi fuel elements. The fuel was manufactured in the fuel fabrication facility, Building 73. The natural uranium fuel elements were irradiated in the IRT-5000 reactor by removing a Be reflector and replacing it by a fuel element. The irradiated fuel elements were disassembled in the Tamuz-2 hot cell, and

Table 2

Summary of inspection results

7TH ON-SITE INSPECTION
LOCATION C

UNSC 687

MATERIAL TYPE		ORIGIN Processing Site	PRESENTED TO TEAM TEAM No	DECLARED INVENTORY			VERIFIED INVENTORY				LEFT UNDER SEAL Y/N
				No. of Items	Compound Weight (kg)	Element Weight (kg)	VERIFICATION I	NDA	B	D	
Yellow Cake		Niger	1, 3	430	138744	100200	430	156	55	18	Y
		Portugal	1, 3	915	286435	213016	915	321	121	44	Y
NATURAL URANIUM	UO_2 Pellets	Previous Safeguards	4	47	28.10	23	1	1	1	1	Y
	U_3O_8 Powders		1, 3		1360.7	1162	10	6	4	2	Y
	UO_2 Powders		1				22	18	7	2	Y
	UO_4 Powders		1				1	1	1	1	Y
	Mixed Oxides		1				6	6	3	1	Y
	UO_4 Slurry		4				8	8	8	2	Y
	UO_4 Filters		4	37	*	50	37	*	*	1	Y
	Liquid Waste	Brazil/ AL.T. Bld 18	4	4	*	8	4	*	*	1	Y
	UO_2 Powders	Brazil	3, 4	227	22578	19643	227	48	227	10	Y
	UF_6	Brazil/ AL.T. Bld 18	3	1	0.466	0.312	1	1	1	1	Y
	UF_4 Powders	Brazil/ AL.T. Bld 18	1, 3	6	358	233	5	4	4	3	Y
	UCL_4	Brazil/ AL.T. Bld 18	3, 4	43	1520	957	43	41	25	9	Y

I = Item counting B = Weighing D = Sampling and analysis NDA = Non-destructive analysis

*This table does not include the Nuclear Material present at Tikrit (138 tonnes compound weight of yellow cake of Niger origin, 3000 kg compound weight of yellow cake produced at Al-Qaim and 2255 kg compound weight of UO_4 processed in Al-Mosul).

.../...

Table 2 (continued)

7TH ON-SITE INSPECTION
LOCATION C

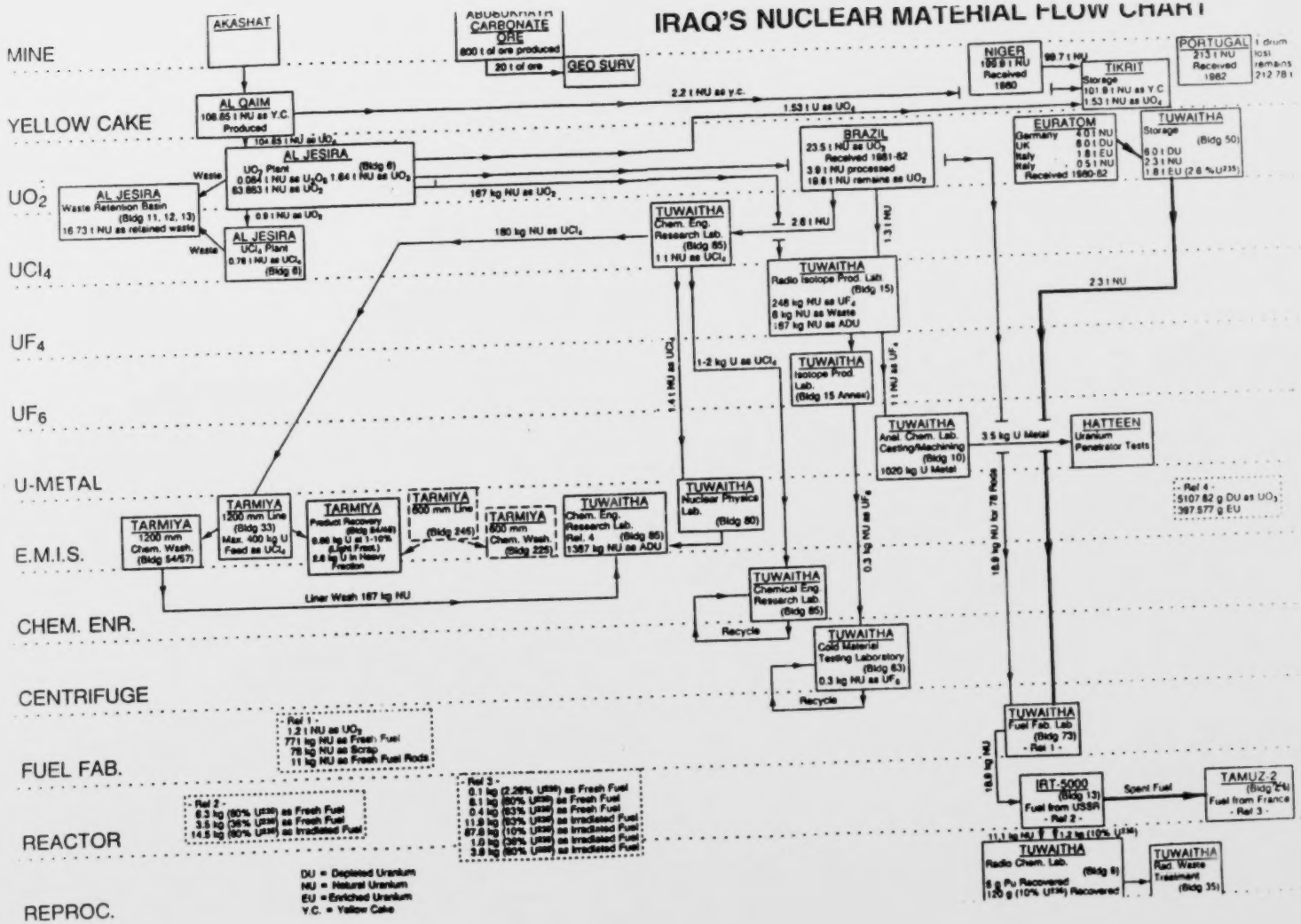
UNSC 687

MATERIAL TYPE		ORIGIN Processing Site	PRESENTED TO TEAM TEAM No	DECLARED INVENTORY			VERIFIED INVENTORY				LEFT UNDER SEAL Y/N
							VERIFICATION				
				No. of Items	Compound Weight (kg)	Element Weight (kg)	I	NDA	B	D	
NATURAL URANIUM	U Metal	Brazil/ Al. T. BLD 10	4	22	1000	1000	22	7	21	3	Y
	ADU Powders	Brazil/ Al. T. BLD 85	3	31	1850	1387	31	-	3	1	Y
	Liquid Recovery	Brazil/ Al. T. BLD 85	3	2	-	-	2	-	2	29	Y
	ADU Powders	Al-Qaim/Al-Mosul	4	3	220	165	3	3	3	4	Y
	UO_4		3	2 samples	-	-	2	1	2	4	Y
	U_3O_8		4	4	100	84	4	4	4	1	Y
	UCl_4		3	8	1207	780	8	8	8	3	Y
	UO_3 Powders		3	44 *	2050	1701	8	8	8	12	Y
	UO 4 Powders						2	2	2	1	Y
	Mixed Oxides						19	19	19	2	Y
	UO_2 Powders		3	409	96095	83883	409	307	97	41	Y
	SCRAP	Al-Tuwaitha	3	1	-	-	1	-	1	1	Y

I = Item counting B = Weighing D = Sampling and analysis NDA = Non-destructive analysis
* Rebatched and categorized during inspection

/...

Figure 10


IRAQ'S NUCLEAR MATERIAL FLOW CHART
MINE
YELLOW CAKE
UO2
UCl4
UF4
UF6
U-METAL
E.M.I.S.
CHEM. ENR.
CENTRIFUGE
FUEL FAB.
REACTOR
REPROC.
AKASHAT
ABUSUDAIR CARBONATE ORE
800 t of ore produced
20 t of ore
GEO SURV
AL QAIM
106.85 t NU as Y.C.
Produced
2.2 t NU as y.c.
1.53 t U as UO4
NIGER
99.7 t NU
TIKRIT
Storage
101.9 t NU as Y.C
1.53 t NU as UO4
PORTUGAL
1 drum lost remains
213 t NU
Received 1982
212.78 t
AL JESIRA
UO2 Plant
(Bldg 6)
0.084 t NU as U3O8 1.64 t NU as UO3
63.853 t NU as UO2
10+.85 t NU as UO4
167 kg NU as UO2
0.9 t NU as UO2
AL JESIRA
Waste Retension Basin
(Bldg 11, 12, 13)
16.73 t NU as retained waste
AL JESIRA
UCl4 Plant
0.78 t NU as UCl4
(Bldg 8)
180 kg NU as UCl4
BRAZIL
23.5 t NU as UO2
Received 1981-82
3.9 t NU processed
19.6 t NU remains as UO2
EURATOM
Germany 4.0 t NU
UK 8.0 t DU
Italy 1.8 t EU
Italy 0.5 t NU
Received 1980-82
TUWAITHA
Storage
(Bldg 50)
8.0 t DU
2.3 t NU
1.8 t EU (2.6 %U235)
TUWAITHA
Chem. Eng. Research Lab.
(Bldg 85)
1.1 kg NU as UCl4
2.8 t NU
1.3 t NU
TUWAITHA
Radio Isotope Prod. Lab.
(Bldg 15)
248 kg NU as UF4
8 kg NU as Waste
167 kg NU as ADU
2.3 t NU
1.41 NU as UCl4
1-2 kg U as UCl4
TUWAITHA
Isotope Prod. Lab.
(Bldg 15 Annex)
1.1 NU as UF6
TUWAITHA
Anal. Chem. Lab.
Casting/Machining
(Bldg 10)
1020 kg U Metal
3.5 kg U Metal
HATTEEN
Uranium Penetrator Tests
Ref 4 -
5107.82 g DU as UO2
397.577 g EU
TARMIYA
1200 mm Chem. Wash.
(Bldg 54/57)
TARMIYA
1200 mm Line
(Bldg 33)
Max. 400 kg U
Feed as UCl4
TARMIYA
Product Recovery
(Bldg 54/48)
0.66 kg U at 1-10% (Light Frac.)
8.8 kg U in Heavy Fraction
TARMIYA
1600 mm Line
(Bldg 245)
TARMIYA
1600 mm Chem. Wash.
(Bldg 225)
TUWAITHA
Chem. Eng. Research Lab.
Rel. 4
(Bldg 85)
1397 kg NU as ADU
TUWAITHA
Nuclear Physics Lab.
(Bldg 80)
Liner Wash 167 kg NU
0.3 kg NU as UF6
18.8 kg NU for 78 Rods
TUWAITHA
Chemical Eng. Research Lab.
(Bldg 85)
Recycle
TUWAITHA
Cold Material Testing Laboratory
(Bldg 83)
0.3 kg NU as UF6
Recycle
TUWAITHA
Fuel Fab. Lab
(Bldg 73)
- Rel 1 -
18.8 kg NU
IRT-5000
(Bldg 13)
Fuel from USSR
- Rel 2 -
Spent Fuel
TAMUZ-2
(Bldg 24)
Fuel from France
- Rel 3 -
11.1 kg NU
1.2 kg (10% U235)
TUWAITHA
Radio Chem. Lab.
(Bldg 9)
6 g Pu Recovered
120 g (10% U235) Recovered
TUWAITHA
Rad. Waste Treatment
(Bldg 35)
- Rel 1 -
1.2 t NU as UO2
771 kg NU as Fresh Fuel
78 kg NU as Scrap
11 kg NU as Fresh Fuel Rods
- Rel 2 -
6.3 kg (80% U235) as Fresh Fuel
3.5 kg (36% U235) as Fresh Fuel
14.5 kg (80% U235) as Irradiated Fuel
- Rel 3 -
0.1 kg (2.26% U235) as Fresh Fuel
8.1 kg (80% U235) as Fresh Fuel
0.4 kg (93% U235) as Fresh Fuel
11.9 kg (93% U235) as Irradiated Fuel
87.2 kg (10% U235) as Irradiated Fuel
1.0 kg (36% U235) as Irradiated Fuel
3.9 kg (80% U235) as Irradiated Fuel
DU = Depleted Uranium
NU = Natural Uranium
EU = Enriched Uranium
Y.C. = Yellow Cake

.../

individual fuel pins were transported to Laboratory C-1 in Building 9. Chopping and dissolving occurred in hot cell SC-1. Uranium and plutonium were separated from fission products in hot cell SC-3 in two banks of mixer-settlers with 16 cells in each bank. All zircaloy hulls from the three Iraqi fuel elements are stored in cans at the back of hot cell SC-2.

48. Uranium and plutonium were transferred from hot cell SC-3 to glove box GB 9, which contained the "accountability" and acid and valence adjust tanks. The solution was then pumped to glove-box GB 10, which contained two banks of mixer-settlers of 16 cells each for uranium-plutonium partitioning and plutonium recovery. Plutonium was batch-transferred to glove box GB 17 and concentrated using a heated mantle. No attempt was made to recover rare gases or iodine; they were vented to the atmosphere.

Waste from the exempted campaign was shipped to Building 35, where it was bitumenized. The bitumenized waste is stored in shielded casks in the waste storage building.

About 400 litres with 350 Ci of waste from the Iraqi campaigns is stored under Building 9 in two waste storage containers - one for aqueous and one for liquid waste. No attempt was made to recover neptunium from any of the four campaigns.

The campaigns were as follows:

3045EK10 exempted fuel	April 1988	2.26 g Pu
1st EK07 14 pins cassette	Nov 89 - Feb 90	0.506 g Pu
2nd 3rd EK07	1 May 90 - 30 Jul 90	2.2 g Pu
(32 pins per cassette)		

The dissolving time was the bottleneck in the process; this suggests a maximum capacity of 60 g Pu/year without modification of the installation.

Plutonium-238 production

49. Microgram amounts of plutonium-238 had been produced from neptunium (Np^{237}) obtained commercially. The declared remaining neptunium is stored in two vials in glove box GB 4 of Laboratory C-2 in Building 9 and should be shipped by the next inspection team. The neptunium was irradiated in the IRT-5000 reactor. The plutonium-238 was reportedly recovered in glove box GB 2 of Laboratory C-2.

Polonium-210 production

50. Microgram amounts of polonium-210 had been prepared by irradiating bismuth in the IRT-5000 reactor. Several irradiations were performed from the end of 1988 to 1990, starting with gram quantities and working up to kilogram quantities. The polonium was recovered in glove boxes in the polonium laboratory on the second floor of Building 9. The laboratory was extensively damaged during the bombing and the glove boxes were broken. Four of the six declared boxes were removed and are now located in

a field near Al Tuwaitha. Three broken boxes were mildly and one severely alpha-contaminated.

The starting bismuth was 99.95% pure. No attempt was made to recover the bismuth. [The bismuth and polonium waste residue was placed in 15 or 16 drums in a bitumenized trench with a bitumen cover at the waste storage site]. Some surface alpha contamination is present at the site from the rupture of some drums during the bombing.

Lithium-6 production

51. A laboratory for lithium-6 production existed in Building 90 but was completely destroyed during the bombing. The enrichment was performed by solvent extraction using crown ethers in a small-scale single rotating axial column. Approximately 0.5 - 1 kg of lithium passed through the column per annum. The highest single-stage enrichment factor was 1.03.

It was claimed that the lithium-6 work can be considered a continuation of work performed under an IAEA contract on the use of crown ethers for radiochemical separation for environmental purposes. A statement was made about the wish to continue the work in order to separate calcium isotopes for medical purposes.

None of the laboratory equipment is reported to exist and no files were produced, although requested. The office building connected to the facility was visited and, although all windows were damaged, all files should have survived. It was claimed that all files were destroyed by the bombing.

OTHER ACTIVITIES

Destruction of glove boxes and manipulators

52. In Laboratory C-1 all cables for manipulators in hot cells SC-1, SC-2, SC-3 and JC-2 were destroyed. The manipulator parts are stored under seal in the manipulator repair shop along with the four previously sealed, unused manipulators. The room is sealed. All glove boxes (15 in total) in laboratories C-1 and C-2 were filled with cement to a depth of 5-10 cm. The new unused glove boxes in the decontamination laboratory, C-3, were disconnected and moved to Building 14 A. Laboratories C-1 and C-2 were sealed with wire and paper seals. Three manipulators and a periscope stored outside the Lama facility were removed to Building 14 A. In addition to the training manipulator from Building 35, all other undamaged manipulators in different buildings are under seal; the seals were verified.

A number of activities have been identified for follow-up.

Destruction of EMIS and Centrifuge Components

53. A large amount of EMIS and centrifuge equipment was destroyed during the seventh inspection. A detailed inventory of the centrifuge components destroyed is provided

in Table 3. All known centrifuge components are now destroyed or were removed by the inspection team. Table 4 describe centrifuge-related items or manufacturing equipment destined for future destruction or monitoring. The full inventory of EMIS components, now stored at Al Nafad, is given in Annex 4. Most of this equipment was destroyed during the bombing or by the Iraqi military during its unsuccessful attempt to conceal the EMIS program. A few vacuum chambers were still fairly intact and were destroyed in the presence of the seventh team. The double-pole magnet cores, end pieces and portions of return iron have been inventoried and marked; they will be destroyed when the means to do so are found.

54. The following EMIS-related items were destroyed by having pieces cut out from each with a plasma torch:

1	1200 mm Vacuum Chamber Die
1	600 mm Vacuum Chamber Die
5	1200 mm Vacuum Chambers
2	600 mm Vacuum Chambers
1	106 mm System Chamber
2	Small Experimental Chambers
2	600 mm Vacuum Ducts
2	1200 mm Vacuum Ducts
19	Misc. 1200 and 600 mm Vacuum Chamber Cones

The following centrifuge-related items were destroyed using a large press or cutting-welding torches:

2	Centrifuge Test Jigs
2	Complete Oil Centrifuges
3	Oil Centrifuge Cylinders
7	Centrifuge Jackets
1	UF_6 Feeding System
5	Boxes of miscellaneous parts

Levelling of buildings at Al Tuwaitha

55. During the fifth IAEA inspection mission it was noted that a number of destroyed buildings at Al Tuwaitha had been levelled. The Iraqi authorities stated that this had been done because of the danger of their collapsing. The attached Al Tuwaitha site map indicates these buildings. The Iraqi authorities wish to level additional buildings for similar reasons, and their request is under consideration.

Activities at PC-3 Headquarters and the Nuclear Design Centre

56. During the sixth IAEA inspection mission, the team had applied IAEA seals to two safes and a metal cabinet at the Nuclear Design Centre and to a room at PC-3 Headquarters containing about 800 files with procurement, budget and training records.

Table 3

List of centrifuge components selected for immediate destruction

Stored in Warehouse 13b - Ash Shakyli (Al Tuwaitha)

Item	Quantity
Recipients with holes	4
Recipients with holes and pumps	2
Recipients without holes	1
Recipients of different design and 2 loose pieces	2
Top flanges	54
Top flange with damper	1
Test jigs	2
Set of piping with valves and vacuum circuit; components contained in a wooden crate	1
Aluminium cylinders for rotors - one with end caps	3
Maraging steel cylinders [2 full length & 3 shorter ones]	5
Molecular pumps	5
Carbon fibre cylinders	7
Scoop assembly (1 with manifold)	2
Tube (approx. 1 cm x 15 cm)	8
Inner magnet holder	28
Ring (approx. 1 cm OD)	107
Tube (approx. 1 cm x 45 cm) (scoop part)	19
Tube (approx. 1 cm x 30 cm) (scoop part)	18
Sensor holder	36
Lower bearing spacer	10
Upper damper spacer	6
Upper damper (3 cm Dia. x 6 cm)	8
Flange-spacer ring	4
Small sensor holder	6
Scoop assembly part (2 cm OD x 4 cm)	17
Scoop assembly part-tube (15 cm Dia x 7 cm)	27
U-cup upper damper part	5
K-F flange upper manifold part	6
Magnet outer holding ring (1.5 Dia x 6.5)	13
Washer (0.5 cm Dia x 4.5 cm)	29
Washer (0.4 cm Dia x 3 cm)	31
Scoop ring (3 cm Dia x 2 cm)	9
Lower bearing housing cover (5 cm Dia x 1.5 cm)	3
Ring (8 cm Dia x 1 cm)	1
Lower damper spacer	2

Table 3 (continued)

Item	Quantity
Ring (2 cm Dia x 1 cm)	4
Rocker arm	20
Pin for assembling (lower assembly) (0.3 cm Dia x 4 cm)	18
Spacer (0.6 cm x 0.2 cm)	55
Tubes for scoop assembly; Al (1 cm Dia x 84 cm)	10
Tubes for scoop assembly; Al (1 cm Dia x 74 cm)	20
Tubes for scoop assembly; Al (1.5 cm Dia x 35 cm)	23
Tubes for scoop assembly; Al (approx. 1.4 cm Dia x 50 cm)	5
Rings (10.5 cm OD x 1 cm) Motor coil	5
Cu scoop material (straight) (0.4/0.6 x 24 cm) (tapered)	20
Motor stator spacer (approx. 1.3 cm x 1.3 cm)	80
Tube (tails pipe for scoop assembly) (2.2 cm Dia x 20 cm)	22
Maraging steel rotor top cap	38
Carbon machine top baffle	7
Carbon machine top cap	10
Carbon machine bottom cap	1
Aluminium top rotating magnet holder (small)	13
Aluminium bottom damper skirt	76
Aluminium top rotating magnet holder (large)	6
Bottom damper housing	25
Spacer flange	16
Top damper housing	9
Bottom damper cover	14
Adjusting screw	21
Parts of scoop assembly	19
Pivot holder (brass)	18
Maraging steel top rotating magnet holder	41
Feed shroud	66
Feed input flange	47
Bottom bearing flange	22
Feed port	24
Top scoop holder	27
AlNiCo magnet holder	43
Part of top scoop	54
Bottom scoop boss	24
Washer	18
Top damper adjusting screw	60
Part of lower damper	30
AlNiCo magnets	84
CoSm magnets	49
Gas manifold	82
Transport shield for protection	1
Aluminium bottom flange	16

Table 4

Centrifuge-related items for future destruction or monitoring

WAREHOUSE 13b, ASH SHAKYLI (AL TUWAITHA)

Item	Quantity
Valves (VAT & Nupro)	700
Oil (Fomblin) Vacuum pump oil - Krytox	100 Liters
Horizontal balancing machine	1
Vertical balancing machine	1
Frequency converters - Acomel	2
Assembly presses	2
Vacuum pumps - rotary	22

DAURA - STATE ENTERPRISE FOR HEAVY ENGINEERING EQUIPMENT

Item	Quantity
Flow turning machine	1
Mandrel	1
Expanding mandrel	1
Electron beam welding chamber and all associated apparatus	1
Oxidation furnaces and all associated apparatus	2
MIG welding equipment (for recipients)	1
Brazing furnace and associated apparatus	1
Heat treatment furnace and associated apparatus	1
CNC machines	3

BADER ENGINEERING SITE

Item	Quantity
CNC machines	10

The seventh IAEA team inspected these locations. The safes and the metal cabinet were found to be empty by the team after it had broken the seals. The files in the room at PC-3 Headquarters were all examined (approx. 10 000 pages of documents) and a selection of relevant procurement, budget and training documents was made. These documents were brought to Vienna and added to the documentation brought by the sixth team and awaiting further analysis. No problems from the Iraqi side were encountered.

The Al Kadisya State Establishment

57. The Al Furat site was originally a school for technicians. The training area (now designated as Building 800) had been reconfigured for the centrifuge manufacturing program. The remaining buildings are barracks and small support buildings. These buildings are unused. The north-east corner of the Al Furat site contains a separately fenced area (fig. 7). When the team requested access to this area for inspection purposes, the Iraqi authorities stated that the area belonged to another firm (the Al Kadisya State Establishment) and that a formal designation was required. This was quickly arranged, and the inspection proceeded. The area used to be part of the technician training centre that comprised the Al Furat site. The three larger buildings in this area are two barracks and a warehouse/storage building. The barracks are essentially untouched. Several rooms are being used as offices. The warehouse has been converted into a small machine shop used for some rudimentary robotics development work.

Uranium mine at Abu Sukhayr

58. This is an exploratory mine located approximately 25 km south-west of Najar. Prospecting started in September 1988 and ended at the end of 1990, when the mine was flooded by water from an aquifer. Twenty-five people were employed in all. The shaft was stated to be 75 m deep, with the galleries extending for 150 m, and the ore thickness 50 cm. Because of the flooding, it was not possible for the inspectors to enter the shaft to check these statements.

The total production during the time the shaft was in operation was stated to have been 800 tons of Marley limestone with an average uranium content of 150 ppm. The range varied from 80 to 800 ppm. Samples were taken from both crushed and uncrushed ore for analysis to verify this statement.

Apart from some 20 tons of ore stated to have been sent to the HQ organization ("General Establishment for Geological Survey and Prospecting"), all material extracted was on the site. The manager stated that drilling had been abandoned and that there was no intention to restart. The general appearance of the site supported this statement.

No records were available, it being claimed that everything in the administrative offices was destroyed following the war. The offices were portable cabins and caravans (trailers), which had clearly been completely wrecked.

The uranium content of the ore is two to three times higher than that of the ore at Akashat, which formed the feed to the uranium extraction plant to Al Qaim. It would probably be worthwhile for Iraq to carry out further exploration if a decision were taken in the future to resume nuclear activities.

ANNEX 1

IRAQI ATOMIC ENERGY COMMISSION

No:

Date: 14 October 1991

With reference to your letter of 12 October 1991 concerning what you call "weaponization", I wish - before responding to the contents of that letter - to affirm the following facts:

1. Iraq has officially confirmed the abandonment of its nuclear programme, the latest such confirmation being contained in the letter dated 10 October 1991 from Iraq's Minister of Foreign Affairs addressed to the Director-General of the International Atomic Energy Agency.

2. There is no Iraqi political decision to manufacture nuclear weapons.

3. There is no Iraqi programme to produce nuclear weapons or explosives.

4. Al-Athir Centre was designed to be a national materials centre and represents the missing link in Iraqi industry and technology. The extent of the losses suffered by Iraqi industry as a result of the problems concerning materials imported for industrial purposes are no secret to anyone. However, the centre could - at the same time - cover important aspects of the weapons programme if such a thing were to be decided upon or desired.

5. Various research and studies of the sort to which you refer as "weaponization" have been carried out. The objective in carrying out such research and studies was to establish the practical, technical and scientific requirements for a programme of this nature in the event that a political decision were to be taken to proceed in that direction. The intention was that the political leadership should be apprised of these requirements so that it might consider them - together with the political implications - and then take an appropriate decision on a topic of such significance. We affirm that there was no political decision - as of the the time when the 30-nation aggression was launched against Iraq - to manufacture nuclear weapons or nuclear explosives in any shape or form whatsoever.

Mr. Demetrius Perricos
Chief, 7th International Nuclear Inspection Team

/...

6. Al-Athir Centre was put into operation in approximately mid-1990. From the outset and until the beginning of the aggression on the night of 16/17 January 1991, its activity revolved around matters of installation, organization and testing. Furthermore, parts of the centre are still under construction and remain uncompleted, with civil works still in progress. No scientific research, study or practical work had begun at the centre as of the beginning of the aggression on the night of 16/17 January 1991.

7. Accordingly, none of the research and studies carried out - the questions concerning which will be answered by us - were performed at al-Athir Centre.

8. In conclusion, we affirm once again that all the research and studies carried out and described by you as "weaponization" consist of laboratory-level research not designed to lead to the production of weapons.

Please accept my respects.

(Signed) Dr. Abd al-Halim Ibrahim AL-HAJJAJ
Head of the Iraqi Team

Enclosures: Answers to question 1

ANNEX 2

IRAQI ATOMIC ENERGY COMMISSION

No: 2300/920/177

Date: 21 October 1991

Further to our letter of 14/10/1991, I wish to add the following concerning Al-Athir Centre for Materials Production Development, in order to avoid any possible confusion and to ensure further clarification:

1. All research and studies carried out under the heading of what you have decided to call "weaponization" were carried out by operational and technical teams belonging to Group IV of the project. All such activity was conducted at this Group's work-sites in Tuwaitha, apart from the plane lens experiments, which were conducted at the Hatteen Establishment explosives laboratory.

The intention was that the teams in this Group be returned to their original jobs, depending on area of specialization, after completing their specific task (to determine the operational, technical and scientific requirements for a weapons programme if a political decision should be taken to proceed). These teams would of course serve as the core for such a programme if it were decided to proceed in the future.

In 1990, this Group was given the code name "Al-Athir Plant".

The Group was headed by Dr. Khalid Ibrahim Sa'id.

2. Al-Athir Centre for Materials Production Development is an entirely separate subject, bearing no relation to the work of this Group. It was established to serve the country's industrial establishments, with the Ministry of Industry assuming responsibility for coordination and supervision. Dr. Khalid Ibrahim Sa'id chaired the Centre's steering committee.

He, of course, ordered whatever he felt was necessary to meet the design requirements for the buildings which could serve the possible programme if a decision were to be taken to proceed in the future, including the possible use of Al-Athir Centre for such a programme, in addition to its fundamental uses.

In any event, Al-Athir Centre has not yet commenced operations of its current programme as a national materials centre. It was definitely not used to carry out the research and studies which you refer to as "weaponization".

We hope that we have thus provided an adequate explanation of the separation between Al-Athir Centre and what you call "weaponization".

Yours sincerely,

(Signed) Abd al-Halim Ibrahim al-Hajjaj
Head of the Iraqi Team

Mr. Demetrius Perricos
Chief, Seventh International Nuclear Inspection Team

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ANNEX 3

LIST OF DOCUMENTS AND DECLARATIONS SENT OR RECEIVED

7-1. Mr. Perricos to Mr. Al Hajjaj on 911012 - requesting information on gaseous centrifuge enrichment, gaseous diffusion enrichment, laser isotope separation, chemical enrichment, reprocessing and plutonium production programs, and the general organization of the nuclear program.

7-2. Mr. Perricos to Mr. Al Hajjaj on 911012 - requesting information on various aspects of the weaponization program.

7-3. Mr. Perricos to Mr. Al Hajjaj on 911012 - referring to a meeting on 911012 and requesting additional information on the 93 % U-235 observed in some samples and providing lead questions about weaponization.

7-4. Mr. Perricos to Mr. Al Hajjaj on 911012 - requesting a list of equipment collected at a location at Al Tuwaitha, indicating the origin of such equipment, and a schedule for the future movements of the equipment.

7-5. Mr. Al Hajjaj to Mr. Perricos on 911013 - providing a list of the EMIS program equipment transferred to location T at Al Tuwaitha (Note: Upon inventory-taking some modifications to the list provided were made).

7-6. Mr. Al Hajjaj to Mr. Perricos on 911012 - providing answers to some questions put by the fifth team on 910920 about mass spectrometers, electrochemical cells and mixer-settlers.

7-7. Mr. Al Hajjaj to Mr. Perricos on 911014 - referring to paras 3 and 4 of letter of 911012 (item 7-1 above), concerning laser and chemical enrichment.

7-8. Mr. Al Hajjaj to Mr. Perricos on 911014 - referring to enquiry of 911012 (item 7-3 above) regarding uranium enriched to 93 %.

7-9. Mr. Al Hajjaj to Mr. Perricos on 911014 - referring to letter of 911012 (item 7-3 above), concerning the high-speed cameras and capacitors and providing a sample of such a capacitor.

7-10. Mr. Al Hajjaj to Mr. Perricos on 911014 - referring to para.7 of letter of 911012 (items 7-1 and 7-2 above), concerning the organization of nuclear and weaponization program activities.

7-11. Mr. Al Hajjaj to Mr. Perricos on 911015 - response to para.5, concerning fuel reprocessing and plutonium production, of letter of 911012 (item 7-1 above).

7-12. Mr. Al Hajjaj to Mr. Perricos on 911015 - response to letter of 911012 (item 7-2 above), regarding project 144 and the HMX explosives.

7-13. Mr. Al Hajjaj to Mr. Perricos on 911015 - response to the paras 1.1.1 to 1.2.5 of letter of 911012 (item 7-2 above), regarding weaponization.

7-14. Mr. Al Hajjaj to Mr. Perricos on 911015 - response to paras.1 and 2, concerning the enrichment and the gaseous diffusion centrifuge method, of letter 911012 (item 7-1 above).

7-15. Mr. Al Hajjaj to Mr. Perricos on 911015 - notifying, in response to letter of 911012 (item 7-4 above), the transfer of the equipment of the electromagnetic separation program from the destruction sites to the Al Tuwaitha site.

7-16. Mr. Perricos to Mr. Al Hajjaj on 911016 - summarizing the points discussed at a meeting on 911015 (which included the availability of machines to cut the magnets of the EMIS program; the destruction of the dies used for the EMIS program magnets at Daura; the return of the microfilms and microfiches of the sixth inspection team; the presentation of the chemical enrichment columns; information regarding the buildings levelling operations at Al Tuwaitha; a list of the universities which have received the mass spectrometers; a list of the facilities which have received the graphite equipment; arrangements for a visit to the Saladdine establishment and the Abu Sukhayr mine, a list of the centrifuge parts to be destroyed; the destruction or rendering harmless of equipment in glove boxes and of certain manipulators; the further investigation of the import of maraging steel to Iraq; and a statement on the number of beryllium rods.

7-17. Mr. Al Hajjaj to Mr. Perricos on 911016 - response to para.2, concerning the development of analytical tools, and para.3, concerning experimental programs, of letter of 901012 (item 7-2 above).

7-18. Mr. Al Hajjaj to Mr. Perricos on 911016 - providing information on the inventory of beryllium rods in response to letter of 911016 (item 7-16 above).

7-19. Mr. Perricos to Mr. Al Hajjaj on 911017 - stating that advance notification and agreement with the IAEA are required before the removal of any seals on items and/or material and/or the removal of items to other locations. The IAEA will provide a list of seals once the team returns to Vienna.

7-20. Mr. Al Hajjaj to Mr. Perricos on 911017 - requesting copies of videofilms and photographs taken by the team at Al Atheer on 911016.

7-21. Mr. Al Hajjaj to Mr. Perricos on 911017 - requesting copies of videofilms and photographs taken by the team at Al Hatteen on 911017.

7-22. Mr. Al Hajjaj to Mr. Perricos - answers to questions 1 and 4, concerning material production, of letter of 911012 (item 7-2 above).

7-23. Mr. Perricos to Mr. Al Hajjaj on 911019 - additional questions regarding matters connected with uranium enrichment (such as serial numbers on molecular pumps, strip chart in an oxidation furnace, the location of mandrels, the machine used for the preparation of groovings, the machine used for welding the ball to the needle, a request for the top and bottom bearings and the motor of the molecular pumps, and information on the manufacturer and technology of the motor and on the laboratory used for the diffusion research) arising out of the on-site inspection activities carried out on 911017.

7-24. Mr. Perricos to Mr. Al Hajjaj on 911019 - requesting a discussion on the research on laser isotope separation (AVLIS and MLIS) in Iraq.

7-25. Mr. Perricos to Mr. Al Hajjaj on 911019 - referring to letters of 911017 (items 7-20 and 7-21 above) and agreeing to provide a copy of relevant film and pictures later through the Iraqi Permanent Mission in Vienna.

7-26. Mr. Perricos to Mr. Al Hajjaj on 911019 - requesting certain documents related to the inspection activities performed at Al Atheer, Al Qa Qaa and Al Hatteen and the second list of centrifuge-related items to be destroyed or rendered harmless.

7-27. Mr. Perricos to Mr. Al Hajjaj on 911020 - requesting the production records of the Al Qaim and Ash Sharqat mines in the light of ore sample analysis results.

7-28. Mr. Perricos to Mr. Al Hajjaj on 911020 - asking for additional information on: nuclear sources currently under IAEA paper seals at location C; UO_2 and UO_3 from Al Mosul; uranium solutions and powders from Building 85; uranium metal production; and tare weights of a UF_6 cylinder and the UO_2 drums from Al-Mosul.

7-29. Mr. Al Hajjaj to Mr. Perricos on 911020 - answer to letter of 911017 (item 7-23 above), which had requested additional information on the enrichment program.

7-30. Mr. Al Hajjaj to Mr. Perricos on 911019 - answer to paras 5 and 6 of letter of 911012 (item 7-2 above), concerning the facilities and equipment of the weaponization program.

7-31. Mr. Al Hajjaj to Mr. Perricos on 911019 - answer to request of 911019 (item 7-26 above), with the Al Atheer equipment layout plan.

7-32. Mr. Al Hajjaj to Mr. Perricos on 911019 - answer to para.7 of letter of 911012 (item 7-2 above), stating that information on weaponization is in the documents acquired by the sixth team on 910923 and 910924.

7-33. Mr. Perricos to Mr. Al Hajjaj on 911021 - acknowledging receipt of plutonium solutions.

7-34. Mr. Perricos to Mr. Al Hajjaj on 911021 - requesting: additional information about flying plates; the organization chart of PC3; a description of one- and two-dimensional codes; design specifications of the Al Hatteen bunker; a description of firing tests at the bunker between March and May 1990; a sketch of the explosive lenses used in the tests; sensors used for detonic tests; and information on sites where isostatic presses are located (referring to the meeting with Mr. Said on 911020).

7-35. Mr. Perricos to Mr. Al Hajjaj on 911021 - requesting: additional information on imported beryllium, the return of uranium samples from Al Hatteen to Al Tuwaitha; a statement on the use of buildings at Al Atheer; information on the location of the ion sources of the Al Tuwaitha EMIS units; and information on the removal of equipment from and on the back-up role of Ash Sharqat.

7-36. Mr. Gil-Ramos to Mr. Al-Saji on 911021 - asking for an explanation of the difference between the ICR and source documents for a UO2 shipment made on 820513.

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7-37. Mr. Al Hajjaj to Mr. Perricos on 911020 - response to letter of 911010 (item 7-24 above), stating that there is no laser enrichment activity under way in Iraq.

7-38. Mr. Al Hajjaj to Mr. Perricos on 911021 - requesting the release of a "full" amount of HMX for civilian uses.

7-39. Iraqi Atomic Energy Commission, Annual report 1990.

7-40. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911020 (item 7-28 above), providing a list of radioactive sources stored at location C; giving information on the total production of UO_2 at Al Jesira, on UO_3 and UO_4 from the Al Jesira laboratory, on uranium solutions and powder from Al Tuwaitha Building 85, and on uranium metal; and stating tare weights of UF_6 cylinder and UO_2 drums.

7-41. Mr. Al Hajjaj to Mr. Perricos on 911021 - referring to machines sealed by the seventh on-site inspection team at the Badr General Installation and the General Installation for Heavy Equipment and to plans for using these machines for purposes of civilian production and construction, and asking for views regarding those plans.

7-42. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911021 (item 7-35 above), stating that after sending for destruction they have not been in a position to locate any of the ion sources and collectors, the transformers being moved from Ash Sharkat for use elsewhere, and that Ash Sharqat was selected as a substitute in mid-1988, and when the first Tarmiya separator was commissioned handed it over to the Ministry of Industry, and that there was no programme worked out to move equipment between Tarmiya and Ash Sharqat.

7-43. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911020 (item 7-27 above), providing information on production at Al Qaim.

7-44. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911021 (item 7-35 above), providing information on the use of beryllium.

7-45. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911021 (item 7-35 above), providing a list of buildings at Al Atheer, Al Hatteen and Balat Al Shohadaa.

7-46. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911019 (item 7-26 above), providing a plan of the Al Hatteen establishment.

7-47. Mr. Al Hajjaj to Mr. Perricos on 911021 - reponse to the third question on page 2 of letter of 911021 (item 7-35 above), reiterating that an answer was provided in letter of 910121.

7-48. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to questions about presses at Al Atheer (items 7-2 above and 7-56 below).

7-49. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to questions regarding the cameras used at Al Atheer, stating that the information was provided to the fourth inspection team in a letter dated 910809.

7-50. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911019 (item 7-31 above) providing the equipment layouts in the powder, casting and carbide buildings at Al-Atheer.

7-51. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911019 (item 7-26 above), providing information on the composition of the HMX used.

7-52. Mr. Al Hajjaj to Mr. Perricos on 911021 - reponse to questions 4 and 5 of letter dated 911019 (item 7-34 above), providing information on the design specifications of the bunker and a store.

7-53. Mr. Al Hajjaj to Mr. Perricos on 911021 - reponse to letter of 911017 (item 7-23 above), regarding the welding of the G1.3 cylinder and relevant oxidation process tests.

7-54. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911016 (item 7-16 above), providing a list of the buildings which have been or are to be removed from the Al Tuwaitha site.

7-55. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911016 (item 7-16 above), providing information on the destruction of EMIS equipment at Al Tuwaitha and Daura and stating that: the microfiches and films are still being sought; the chemical enrichment columns have been shown; the mass spectrometers are in the Chemistry Section of the IAEC; the graphite machining equipment has been moved to the Al Rabic plant; inspections were carried out at the Saladdine establishment and Abu Sukhayr; the centrifuge parts have been destroyed; destruction of the glove boxes has been carried out; and, regarding maraging steel, information was provided to the fourth team, but should the Agency have additional information, they would like to receive it for further investigation.

7-56. Mr. Perricos to Mr. Al Hajjaj on 911021 - asking for additional information on the design studies, basic design, lithium, detonators - exploding bridgewire system, hydrodynamic tests, and flash X-ray program.

7-57. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911021 (item 7-56 above), providing a report on the use of exploding bridgewires.

7-58. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911021 (item 7-56 above), providing a report on experiments with plane lenses.

7-59. Mr. Al Hajjaj to Mr. Perricos on 911021 - response to letter of 911021 (item 7-56 above), providing information on the one- and two-dimensional calculations, molecular calculations, neutronics calculations, and distortion and other calculations made.

Annex 4

The Iraqi Uranium Enrichment Program

The Electromagnetic Isotope Separation (EMIS) Process

1. The Iraqi EMIS project has been described at length in the full reports of the third and fourth inspection teams. The EMIS-related activities of the seventh inspection team consisted of:

   (a) detailed inspection of the Ash Sharqat site;

   (b) a verification of EMIS components that have been collected together at two sites near Al Tuwaitha (efforts to complete the destruction of EMIS components were initiated);

   (c) the identification and sealing of manufacturing equipment used in the production of EMIS components.

   The Ash Sharqat site

2. The Ash Sharqat EMIS production site is located about 250 kilometers north of Baghdad. Development of the site began in 1988. According to Iraqi statements, the site was being developed as an alternative to Tarmiya (possibly for some of the activities located at Al Tuwaitha) at a time during the Iran-Iraq War when both the Al Tuwaitha and the Tarmiya site were seen as vulnerable to attack. The facilities at Ash Sharqat are a duplicate of the corresponding facilities at Tarmiya. Iraqi statements indicate that, after the end of the Iran-Iraq War (mid-1989), a decision was taken not to use the Ash Sharqat site for EMIS production.

3. The facilities at the Ash Sharqat site are distributed among three geographically separate locations. The separation was apparently necessary because of the relatively rough terrain. The locations are designated:

Location A	-	electrical and mechanical workshops
Location B	-	main production area
Location C	-	chemical recovery area

   The distance between the locations varies from 1 to 2 kilometers. The facilities were still under construction at the time of the Gulf War. The workshops at location A appear to have been essentially complete. The facilities at the other two locations were 80 - 90 % complete. Construction cranes were still in place at location C when the site was bombarded.

4. The inspection by the seventh team was the second inspection of this site (the first was by the third inspection team, in July 1991). The objectives of the seventh inspection team were: to confirm the judgement of the third team that this site never operated and that no EMIS equipment had been installed there; to complete the characterization of the site; and to discover the nature of the intensive work activity at and near the site since the time of the third inspection.

5. The Ash Sharqat site was extensively damaged during the Gulf War. Of the major buildings, only the mechanical workshop at location A survived relatively intact. The electrical workshop at location A, the main production hall and general utilities building at location B and the chemical recovery facilities at location C were damaged beyond recovery. It has been confirmed that this establishment never operated and that no EMIS equipment was ever installed there. The large amount of infrastructure equipment (transformers, switching gear, water treatment equipment, etc.) that was still in place at the time of the third inspection has been moved to an open storage area to the north and east of location B. The Iraqi authorities stated that this equipment is being made available to other companies in Iraq. The equipment in the storage area was inventoried, but it is clear that many pieces of equipment observed by the third team have been removed from the site altogether. Several samples were taken in the main production and chemical recovery areas.

6. The Iraqi statement that by mid-1989 it had been decided not to use Ash Sharqat as an EMIS site appears credible: at that point in time the Iran-Iraq War was over, the Tarmiya site was nearing completion and Iraqi scientists were having some success with the centrifuge development work at Al Tuwaitha. However, there is no evidence at Ash Sharqat to support this statement: construction work at the site continued as planned; there is no indication that any of the facilities were being reconfigured for some other use; and the installation of infrastructure equipment (most with a 1990 manufacture date) suitable for EMIS but far in excess of the needs for the alternative uses described by the Iraqi authorities was obviously continuing up to the time when the site was attacked. The opinion of the inspection team is that Iraq remained committed to Ash Sharqat as a second EMIS site. The project designation 395 was observed in a number of places.

7. The inspection team also investigated several activities observed along the ridge that runs north-south at the eastern perimeter of the site. Some of these activities were connected with a large bunker located on the hillside due east of location B. It was discovered that the bunker provided access to a very large (approx. 3000 m^3) water storage tank buried in the hillside. The tank, which provides water for the Ash Sharqat facilities, is supplied by pipe from the Tigris river. Other activities included seismic testing connected with petroleum exploration along the ridge and the operation of a stone quarry, with the corresponding accumulation of spoil.

Verification of EMIS components

8. At the end of the third inspection, the Iraqi authorities were requested to move all EMIS equipment to a site in the vicinity of the Al Tuwaitha Nuclear Research Center. This has been done and a new declaration was presented to the seventh inspection team. Ion sources and collectors were presented at a location adjacent to the new dump site, just outside the Al Tuwaitha berm. The remaining equipment is about 3 km from Al Tuwaitha, at Al Nafad. The configuration of the Al Nafad storage site is indicated below.

VACUUM CHAMBERS
- 1200 mm
- 600 mm
- 1000, 500, 400 mm

POWER SUPPLIES
SWITCHING GEAR
DIFFUSION PUMPS

ACCESS ROAD, TUWAITHA →

DOUBLE POLE MAGNETS

- 1200 mm
- 600 mm
- R&D POLES

END PIECES
VERTICAL RETURN IRONS
MAGNET CARRIAGES

COPPER COILS
- 1200 mm
- 600 mm
- R&D POLES

POWER SUPPLIES
WINDING MACHINE

The Iraqi EMIS equipment declaration is presented in Tables 1 - 4. The presentation is organized according to where the equipment had been or was intended to be installed.

9. The Iraqi declaration is consistent with previous information regarding the installation of 1200-mm EMIS equipment at Tarmiya and of R&D equipment at Al Tuwaitha, except for the numbers of ion sources and collectors. The ion sources for the Tarmiya equipment seem reasonably complete, judging by previously established operation and production information, but only 50% of the collectors from the 1200-mm line A separators installed at Tarmiya can be clearly identified (the expected number of collector mounting flanges is present). No ion sources or collectors from the Al Tuwaitha development units have been declared. The quantity of 600-mm EMIS equipment was far greater than that seen by previous inspection teams. The horizontal return irons discovered at Tarmiya during the third inspection have not been moved to Al Nafad. Additional inspection results are summarized below.

(a) The Iraqi declaration describing the EMIS equipment at the Al Nafad and Al Tuwaitha sites has been verified. The extent of the declaration is generally consistent with the known extent of EMIS development and deployment.

(b) Most of the equipment is destroyed. Any key pieces not visibly damaged beyond use (several vacuum chambers and the magnet pole pieces, end pieces and vertical return iron) were marked for destruction. Activities undertaken to destroy this equipment are described later in the report.

(c) Some EMIS-related equipment - 40 diffusion pumps, a large amount of electrical equipment and a coil winding machine - are stored at the Al Nafad site. This equipment is not described in the Iraqi declaration. The coil winding machine is destroyed and the diffusion pumps and electrical equipment have been damaged.

(d) Where it was evident that a collection pocket had been mounted, all sources and collector flanges were sampled. This equipment had been destroyed.

10. The lack of ion sources and collectors from the Al Tuwaitha R&D units remains a concern. The Iraqi authorities indicated that they had been unable to find them and would continue to search. The question of possible EMIS recycling at Al Tuwaitha, necessary for reaching high enrichments, remains open.

EMIS component manufacturing equipment

11. The manufacture of EMIS components was carried out at seven establishments. Their role in the manufacture of EMIS components and the status of the manufacturing equipment were as follows:

(a) Al Radwan and Al Amir - These establishments were involved in the high-precision machining of magnet poles, return irons and various parts of the ion source and collector assemblies. Large-capacity turning and milling machines (5 at Al Radwan and 2 at Al Amir) were identified and sealed.

(b) SEHEE (Daura) - Vacuum chambers for the 600-mm and 1200-mm system were manufactured at Daura. The dies utilized in the manufacturing of the chambers were sealed for identification and later destroyed (see Annex 1).

(c) Al Tuwaitha and nearby location - The copper coil magnet windings were manufactured at these sites. The coil winding machine is destroyed, and the remnants are shown in the inspection team's inventory of the equipment at Al Nafad.

(d) Salladine and Dijila - The assembly of electrical control panels from plans and parts supplied by the Iraqi Atomic Energy Commission was carried out at these sites. No special equipment was involved and nothing remains from the work at these locations. The Salladine plant was established in 1986 under license of a foreign company. Most of the work was with telephone and microwave communication equipment and radar for the Iraqi military.

(e) Al Ameen - The facility at Al Ameen was involved in the manufacture of prototype EMIS components.

The Gas Centrifuge Enrichment Project

12. The centrifuge enrichment project started much later than the EMIS enrichment project. However, its potential had been recognized by the Iraqi authorities and the project was being pursued with equal vigour.

The seventh IAEA inspection team can confirm that, as stated by previous inspection teams, Iraq was following two centrifuge development lines. These were both based on a Zippe type subcritical counter current centrifuge, one using a maraging steel cylinder, the other using a carbon fibre cylinder.

Judging by the manufacturing equipment declared and inspected, the preferred line was the one using maraging steel. The equipment inspected represented everything necessary for mass-producing successful centrifuges. Much of this equipment had not been delivered before early 1990; indeed, some essential equipment was still in its delivery packing cases. Iraq had thus only just started to understand the manufacturing requirements for producing maraging steel cylinders of adequate quality and the necessary tolerances. Also, the means of centrifuge rotor assembly had not been completely mastered. It was therefore necessary to pursue the parallel development line based on a carbon fibre cylinder for single-machine optimization tests. The cylinders were purchased abroad, and rotor assembly was comparatively simple.

From the components seen it is concluded that both lines were in the early stages of development, but it is highly likely they would have been successful. It is believed that lack of experience or manufacturing capability was partially overcome by significant advice from abroad.

13. After inspecting the Al Furat workshop complex and the declared machine tools, jigs and fixtures, it is the team's opinion that the output of the workshop would, in time, have been far greater than that declared by Iraq. Iraq claims that the complex was planned to produce 200 centrifuges a year. An ultimate production capability of 2000 or more centrifuges a year is more likely.

At the time of the inspection, the buildings at Al Furat were devoid of services and equipment, with two of the four main buildings still in the early stages of construction. However, it was stated that one of the buildings had been used for a few months in late 1990 to produce components for development work.

14. A complete inventory of the declared components and equipment was made with the co-operation of the Iraqi authorities. Steps were then taken to destroy immediately the centrifuge components (with the exception of a few pieces removed as samples by the inspection team) and what remained of the R&D test stands. Associated equipment was sealed for future destruction or monitoring.

Following destruction of the specially designed equipment and critical machine tools, Iraq will have difficulty in re-establishing the centrifuge project - provided that there is strict maintenance of export controls by the industrial nations backed up by regular monitoring by the IAEA of Iraq's nuclear industry.

However, since Iraq has not been forthcoming with procurement or project documentation and since there are marked anomalies as regards the numbers of individual components declared, it should be recognized that Iraq may still have an undisclosed program. It is therefore important that future inspection teams continue to press for the release by Iraq of all documentation relating to its centrifuge program and the associated procurement network.

Centrifuge development

15. Initial investigations had been carried out on the flow turning and heat treatment parameters required for the manufacture of the maraging steel cylinder, although evidence of significant help from abroad is apparent. Iraq claims that it had not managed to weld the centrifuge end caps and baffles into the cylinder. The relevant declared equipment was still in its delivery packing cases, but an electron beam welder of sufficient capacity was among the equipment inspected at Al Tuwaitha. The Iraqi authorities stated that the cylinders produced during the last four months of 1990 were of inadequate quality or of unacceptable dimensions for centrifuge use and that all maraging steel centrifuge components had been built for laboratory-scale testing.

16. They further stated that they had procured ten carbon fibre cylinders (the number remains to be confirmed) from abroad and that two centrifuges were assembled using them. The end caps and baffles for these were of maraging steel, and they differed from the components for the all-maraging-steel centrifuge only in the design of the external rim. One of the carbon-fibre-based centrifuges was run in a mechanical test stand, the other in a process test stand. The results were reported by the third and fourth inspection teams. It would appear that the centrifuge used in the process test stand broke down while being tested. The rotor seen by the third inspection team was badly damaged and the vacuum housing was scored in the area opposite the end caps. The rotor from the mechanical test stand remains and has been removed by the IAEA for analysis.

UF_6 Production

17. Only 0.5 kg of UF_6 has been declared by Iraq. It was produced in building 15 at Al Tuwaitha. However, it was sufficient to enable single-machine testing to commence. The UF_6 was fed into the centrifuge and then collected as product and tails in cooled traps. After analysis of the isotopic content, the two streams were mixed together to recreate feed materials.

During the fourth inspection, Iraq informed the team that a UF_6 production facility was to be built eventually in the same building as the UCl_4 production facility at the Al Jesira plant.

Design

18. Both centrifuge development lines were based on the Zippe subcritical counter current centrifuge. For the maraging steel rotor, the end caps and baffles were to be welded into the cylinders; for the carbon fibre rotor, the end caps and baffles were to be held in place using epoxy resin. The rotor was supported on a hydrodynamic bottom bearing and held vertically by a top magnetic bearing. The rotor was driven by an axial hysterisis motor, the rotating element of which was the bottom end cap of the rotor itself.

The rotor was mounted in an aluminium vacuum housing with aluminium end flanges. The housing was mounted into the test stand by a large, centrally mounted collar welded to the housing. A molecular pump was fitted around the top end of the rotor.

Three concentric pipes are mounted centrally from the top flange. UF_6 feed material was fed into the centre of the rotor through one of these pipes. The product and tails were removed through the other two pipes, using 'pitot'-type copper scoops.

Centrifuge components and test facilities

19. The centrifuge components declared by Iraq and shown to the third inspection team remained in the Ash Shakyli warehouse. As promised, the Iraqi authorities had also moved into the warehouse the materials and items declared on the last day of the fourth inspection. After taking samples, the team made a complete, detailed inventory in co-operation with the Iraqi authorities. The inventory is provided in Annex 2. All the items were destroyed under observation of the seventh team.

Also, with the agreement of the Iraqi authorities, the two test stands and the process pipework from the separation test stand were also destroyed. Annex 2 provides a list of those items which were utilized in the R&D program but which have not yet been destroyed, including the high-frequency drive converters.

Manufacturing equipment

20. Visits were made to Badr and SEHEE, the two companies involved in the joint venture to construct a centrifuge manufacturing factory at Al Walid under the code designation "Al Furat project". The machine tools and equipment seen were, in the team's opinion, all that was necessary to commence centrifuge manufacture. Some of them were shown and some were declared on the last day of the mission. The list consists of:

- 11 CNC turning machines of various sizes.
- 2 CNC drilling/milling machines.
- 1 Flow turning machine with its associated mandrel and expanding mandrel.
- 1 Electron beam welding chamber.
- 1 Heat treatment furnace.
- 2 Oxydation furnaces.

- 1 Brazing furnace.
- 1 MIG welding jig.
- 2 Balancing machines (horizontal and vertical).
- 2 Presses.
- 5 High-speed grinding heads with 9 drive converters.

The Iraqi authorities said that the equipment for bottom bearing manufacture (photo table, ultra-violet source, lenses and grooving mask) were kept at Al Tuwaitha and destroyed in the bombing. No equipment was seen, and none for winding carbon fibre cylinders has been declared.

21. All the equipment was sealed, and a list was given to the Iraqi authorities of the equipment which is to be destroyed or monitored. It should be noted that manufacturer identification data had been removed from most of this equipment. Procurement information was still withheld, but it was noted that most of the equipment was dated 1989 or 1990. The experts identified the manufacturers of some equipment, and a list will be made available to relevant governments for further investigation.

22. A visit was also made to the Saddam Engineering Complex, which had been involved in the manufacturing of components for the Type 1 (Beams) centrifuge.

The Al Furat project

23. A visit was made to the Al Furat Centrifuge Manufacturing Complex, which is located close to the Badr Engineering Complex. No construction work has taken place since the fourth inspection team visited the site, early in August. The Iraqi statement regarding the use made of or planned for the four main buildings was as reported by the fourth inspection team.

The Iraqi authorities still claimed that the centrifuge output from the facility was planned to be 200 centrifuges a year starting from January 1992. However, they did concede that it could have been raised to about 400 centrifuges a year through the purchase of critical machine tools. There was sufficient space in the existing buildings to house such additional machine tools since the existing - and planned - buildings are oversized. Also, it was claimed that a reject rate of up to 70% was expected in the early phase of component production. Members of the inspection team with experience of centrifuge manufacturing facilities believe that the facility was quite adequate for producing over 2000 centrifuges a year with time.

The team was shown the area in Building B01 which could have been used for installation of a 100-machine cascade.

Chemical enrichment

24. The Iraqi work has been described in previous inspection reports. According to Iraqi declarations, laboratory-scale work on chemical enrichment involving both the ion-resin and the liquid-liquid process was carried out in Building 90 (located just outside the Al Tuwaitha berm). Iraqi scientists have given presentations about their chemical enrichment work to several inspection teams. The general assessment is that Iraq was not far along in its chemical enrichment work, having managed only to reproduce results reported in different publications.

25. There is very little available in the way of physical evidence or documentation to support (or contradict) the Iraqi declaration. Part of the chemical enrichment equipment is now stored in an outside compound near Building 90. The equipment inspected by the seventh inspection team consisted of:

8	jacketted glass columns (10 cm ID x 203 cm, 15 cm OD)
~ 10	glass columns (8 cm OD x 50 cm)
10	small rotary pumps
5	small stainless steel tanks
3	PTFE sieve plates for 8 cm diameter columns
3	stainless steel sieve plates for 8 cm diameter columns

The large jacketted columns were for ion exchange and the smaller ones for solvent extraction. Smear samples were taken. The diameter of the columns corresponds with information on the scale of the Iraqi chemical enrichment tests provided to the fourth inspection team. The small stainless steel tanks were declared to be for the conditioning of ion exchange resin. The pumps came from two different suppliers. Several showed a 1990 manufacture date.

26. The components inspected are only a part of two separate test rigs for studying the ion-resin and liquid-liquid processes. The space in Building 90 that Iraq states as having been devoted to chemical enrichment work is appropriate to much larger-scale activities than those described to the inspection teams.

It is noted that Building 90 at Al Tuwaitha was declared by the Iraqi authorities to be the location where research on lithium-6 enrichment was taking place.

Gaseous diffusion

27. Regarding work on gaseous diffusion enrichment, Iraq has stated that a theoretical/feasibility study, supported by a modest laboratory effort, was initiated in 1982 and stopped in 1987. The conclusion of the study was that Iraq lacked the infrastructure, both in scope and in materials, to implement the technology. The Iraqi authorities indicated that the sixth inspection team had documentation describing laboratory work on barrier materials, calculations regarding the enrichment process (cascade) and studies on the production of UF_6 gas. This has not yet been confirmed. The work on gaseous diffusion was carried out at Al Tuwaitha (Building 23).

Laser research

28. Iraq has declared that it never pursued uranium enrichment through laser isotope separation. Interviews with Iraqi scientists, sampling results and an inspection of lasers and laser-related equipment (relocated to Building 12 from Building 23) have disclosed no information that contradicts the declaration.

The research equipment in the laser laboratories included infrared, visible and ultraviolet lasers and additional equipment. The additional equipment (e.g., monochromators, oscilloscopes) appears to be consistent with the stated research activities.

Table 1

TABLE SHOWING RESEARCH AND DEVELOPMENT EQUIPMENT AT TUWAITHA

No.	Equipment	No. planned	No. present	Difference	Remarks
1	Half 500-mm-size separator including pole profile, pole face, return iron and coils	2	2	0	At Tuwaitha
2	500-mm-size vacuum chamber	1	1	0	At Tuwaitha
3	Half 1000-mm-size separator including pole profile, pole face, return iron and coils	1	1	0	At Tuwaitha
4	1000-mm-size pole face	5	5	0	At Tuwaitha (destroyed)
5	1000-mm-size return iron	5	5	0	At Tuwaitha (destroyed)
6	1000-mm-size coils	15	15	0	At Tuwaitha (destroyed)
7	1000-mm-size chambers	4	4	0	At Tuwaitha (destroyed), including one test chamber
8	106-system iron	2	2	0	At Tuwaitha (destroyed)
9	400-mm-size pole	6	6	0	At Tuwaitha (destroyed)
10	400-mm-size chamber	1	1	0	At Tuwaitha

Table 2

COMPONENTS OF 1200-SIZE SEPARATORS - FIRST LINE - TARMIYA

No.	Equipment	No. planned	No. present	Difference	Remarks
1	Double pole with double coil	9	9	0	
2	End pole	2	2	0	
3	Vertical return iron (bearing and pole)	2	2	0	
4	Vacuum chambers	8	8	0	At Al Nafad (Tuwaitha)
5	Quadruple sources	8	8	0	
6	Quadruple collectors	8	4	-4*	4 clearly distinguishable at Al Nafad (Tuwaitha) on 24/8/1991
7	Trolleys bearing double poles	9	9	0	At Al Nafad (Tuwaitha) on 24/8/1991
8	Vertical return iron	6	6	0	At Al Nafad (Tuwaitha)
9	Power injectors	59	59	0	Most smashed to pieces, at Al Nafad (Tuwaitha)

* 4 flanges without attachment + 1 rejected flange

Table 3

COMPONENTS OF 1200-SIZE SEPARATORS - SECOND LINE - TARMIYA

No.	Equipment	No. planned	No. present	Difference	Remarks
1	Double pole without coil	18	18	0	
2	Coils	33	41	8	At Tuwaitha on 25/8/1991 including some which failed and some which were not completed
3	End poles	2	2	0	
4	Vertical return iron (bearing end pole)	2	2	0	
5	Other vertical return iron	6	6	0	At Tuwaitha on 25/8/1991; one unmachined
6	Vacuum chambers	17	17	0	At Tuwaitha on 25/8/1991
7	Trolleys bearing double poles	18	18	0	
8	Sources	17	-	-	Under production
9	Collectors	17	-	-	Under production
10	Power injectors	67	67	0	At Tuwaitha on 25/8/1991

Table 4

COMPONENTS OF 600-SIZE SEPARATORS - TARMIYA

No.	Equipment	No. planned	No. present	Difference	Remarks
1	Double pole without coil	6	8	2	+ 2 unmachined
2	Coils	12	10	-2	8 uncompleted coils at Tuwaitha; 2 completed coils at Tuwaitha
3	Return iron	23	23	0	At Al Nafad (Tuwaitha)
4	Coil holders - binary discs	6	6	0	At Al Nafad (Tuwaitha)
5	End poles	2	2	0	At Al Nafad (Tuwaitha)
6	Vacuum chambers	6	6	0	6 at Tuwaitha (3 complete/3 destroyed): 3 evacuation systems at Tuwaitha
7	Sources	6	6	0	Under production: 5 source flanges at Al Nafad (Tuwaitha) and 1 source on 24/8/1991
8	Collectors	6	4*	-2	Under production: 3 collector flanges at Al Nafad (Tuwaitha) on 24/8/1991

* parts of one were widely scattered

Annex 5

Verification of Nuclear Material in Bulk Form

The following verifications were performed:

Yellow cake Niger (100.2 tonnes U content, 430 drums)

1. All drums were counted, 156 drums were verified by non-destructive analysis attribute tests for gross and partial defects, 55 drums were weighed and 18 drums were sampled for destructive analysis.

Yellow cake Portugal (213 tonnes U content, 916 drums)

2. Item counting was performed on 915 drums (1 drum containing 233 kg U was stated to have been lost during the war), 321 drums were verified by non-destructive analysis attribute tests for gross and partial defects, 121 drums were weighed and 44 drums were sampled for destructive analysis.

Natural uranium (previously under safeguards)

3. This includes:

- 1 box containing 23 kg of UO_2 pellets. It was verified by item counting, weighing, non-destructive and destructive analysis.

- 37 filters containing UO_4 with a declared weight of 50 kg U content. They were counted and sampled for NDA.

- Mixed uranium oxides. A total of 1162 kg U content in mixed oxides in 47 items were present at the facility during the November 1990 inspection. The following verifications were performed:

  - 10 items of U_3O_8 powder were counted, 6 of them were verified by non-destructive analysis attribute test for gross and partial defects, 4 of them were weighed and 2 sampled for destructive analysis.

  - 22 items containing UO_2 powder were counted, 18 of them verified by non-destructive analysis attribute test for gross and partial defects, 7 of them weighed and 2 sampled for destructive analysis.

  - 1 item containing UO_4 powder was counted, weighed and verified by non-destructive and destructive analysis.

- 6 items containing mixed uranium oxides were counted and verified by non-destructive analysis attribute test for gross and partial defects, 3 of them were weighed and 1 sampled for destructive analysis.

- 8 drums containing UO_4 slurry were counted, weighed and verified by non-destructive analysis attribute tests for gross and partial defects. In addition, 2 of them were sampled for destructive analysis. These drums were presented with the nuclear material covered by water, which was removed to allow adequate weighing.

UO_2 of Brazilian origin

4. In the declaration of 7 July 1991, the Iraqi authorities declared that they had received 27 tonnes of UO_2 and had processed 7 tonnes of it at Al Tuwaitha. The 20 tonnes of unprocessed UO_2, in 201 drums, were presented to the third team and left under seal at location D. During the seventh inspection this material was brought to location C. In addition, the Iraqi authorities presented natural UO_2 contained in 24 drums and 2 boxes. They declared that this material was part of the 7000 kg originally declared as processed at Al Tuwaitha. Therefore, at present there are 225 drums plus 2 boxes of UO_2 from Brazil, with a total declared weight of 22,578 kg UO_2 (19,642 kg U content).

5. This material was 100% item-counted and weighed, 48 items were verified by non-destructive analysis attribute tests for gross and partial defects, and 10 samples were taken for destructive analysis. The remaining 4422 kg UO_2 (3847 kg U content) processed at Al Tuwaitha were verified as follows:

Material processed in Building 10

- 22 boxes containing U metal (1 tonne U content) were item-counted, 21 were weighed (the remaining box contained small amounts of material as samples), 7 boxes were verified by non-destructive analysis and 3 samples were taken for destructive analysis.

Material processed in Building 15

- 1 cylinder of UF_6 containing 0.465 kg compound weight was weighed and verified by non-destructive and destructive analysis.

- 5 drums of UF_4 powder with an initial declared weight of 359 kg compound weight were counted, 4 of them were weighed (the remaining drum contained small amounts of samples in sample bottles), all of them were verified by non-destructive analysis and 3 were sampled for destructive analysis.

- 4 containers with liquid waste containing a total of 6 kg U content were item-counted and one sample was taken for destructive analysis.

Material processed in Building 85

- 42 drums of UCl_4 plus one drum containing plugs with a total declared weight of 1520 kg of compound material were counted, 25 of them were weighed, 41 were verified by non-destructive analysis and 9 were sampled for destructive analysis.

- 2 drums declared as containing recovered liquid were opened to verify their contents. Since this material belongs to the EMIS enrichment program, it was extensively sampled, 29 samples being taken for destructive analysis. It is estimated that there are around 50 liters in solution form plus around 40 kg in different solid forms in sample bottles.

- 27 drums containing smaller containers plus 4 stainless steel containers with a declared weight of 1850 kg of ADU compound - it was not possible to sort out this material owing to severe contamination in the area. However, during previous inspections 7 items were weighed and 2 sampled.

In order to finally assess the content of this material, all the drums should be emptied and their contents verified. This activity should be performed during the next inspection.

Material of Al Qaim origin

6. This includes the material produced by processing the yellow-cake from Al Qaim. A total of 164 tonnes of yellow-cake was declared as produced at Al Qaim; 3 tonnes are stored at Tikrit and the remaining 161 tonnes (as UO_4) were processed at Al Mosul and presented as follows:

- 1.53 tonnes of U content as (UO_4) were transferred to Tikrit in 9 drums.

- 409 drums with a total declared weight of 96.095 kg of UO_2 which had been presented to the third team were item-counted, 97 of them weighed, 307 verified by non-destructive analysis attribute tests for gross and partial defects and 41 of them sampled for destructive analysis.

- 6 drums were damaged and contained sand, which was removed to determine the amount of UO_2 present in them. After weighing, only one drum had less material than that declared in the itemized list provided by the Iraqi authorities.

- 8 process hoppers containing 1207 kg of UCl_4 were item-counted, weighed and verified by non-destructive analysis. In addition, 3 samples were taken for destructive analysis.

44 containers with a declared weight of 2050 kg of UO_3 were emptied to evaluate their content. It was found that they contained the following material:

- 2020 kg of UO_3. They were placed in 8 drums.
- 200 kg of mixed uranium oxides in 19 containers.
- 58 kg of UO_4 in 2 containers.

All of the above material was item-counted, weighed and verified by non-destructive analysis. In addition, 15 samples were taken for destructive analysis.

- 100 kg of U_3O_8 in 4 containers. These were item-counted, weighed and verified by non-destructive analysis; one sample was taken for destructive analysis.

- 220 kg of ADU, which was presented in 8 drums full of small containers. These containers were emptied into three drums. They were all counted, weighed and verified by non-destructive and destructive analysis.

- 2 drums containing samples of UO_4 were counted and weighed, and 4 samples were taken for destructive analysis.

Scrap

7. 1 drum of scrap was presented to the third team without declaration of its contents. It was weighed and sampled for destructive analysis.

AL JESIRA
AL MOSUL
AL HADRE TEST SITE
ASH SHARQAT
TIKRIT
SALLADINE
AL QAIM
AKASHAT
HASSAR
AL AMEEN
AL RADWAN
AL AMIR
AL QA QAA
TARMIYA
BAGHDAD
DAURA
AL TUWAITHA
DIJJLA
AL FURAT
BADR
AL ATHEER
HAYTEEN HE TEST SITE
IRAQ
ABU SUKHAYR
BASRA